Philips CMS Patient Monitoring System & V24 and V26 Patient Monitors

Concepts Guide

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Contents

Introduction 1
The Purpose of This Book 1
Who Should Use This Book 1
What The Book Contains 2
Intro 2
How the Book is Structured 2
How the Content Is Organized 2
How to Use This Book 3
Learning and Reference 3
Choose Your Approach 3

Basic Plug-In Modules 1
Introduction 1
Goals 1
Objectives 1
Topics 2

Electrocardiogram/Respirogram (ECG/RESP) Module Concepts 3
ECG Measurement 3
Description 3
Concepts 3
Measurement Principle 3
Measurement Acquisition 3
Output 9
Criteria for Proper Measurement 11
Plug-In Modules 11
ECG Measurements Exercises 12
ECG Module 13
Description 13
Measurements 13
Components 13
Block Diagram 13
Theory of Operation (M1001A/M1002A) 15
ECG Module Features 16
ECG Module Exercises 18
RESP Measurement 19

Description 19
Concepts 19
Measurement Principle 19
Measurement Acquisition 20
Output 21
Criteria for Proper Measurement 21
Plug-In Modules 21
References 21
RESP Measurement Exercises 22
ECG/RESP Module 23
Description 23
Measurements 23
Components 23
Block Diagram 24
Theory of Operation 25
ECG/RESP Module Features 26
ECG/RESP Module Exercises 28

Non-invasive Blood Pressure (NBP) Module Concepts 30
NBP Measurement 30
Description 30
Concepts 30
Measurement Principle 30
Measurement Acquisition 31
Output 31
Criteria for Proper Measurement 31
Plug-In Modules 31
NBP Measurements Exercises 32
NBP Modules 34
Description 34
Measurements 34
Components 34
Block Diagram 34
Theory of Operation 36
NBP Module Features 36
NBP Module Exercises 39

Cardiac Output (C.O.) Module Concepts 40
C.O. Measurement 40
Description 40
Concepts 40

Measurement Principle . . . 40
Measurement Acquisition . . . 40
Output . . . 42
Criteria for Proper Measurement . . . 42
Plug-In Modules . . . 42
C.O. Measurement Exercises . . . 43
C.O. Module . . . 44
Description . . . 44
Measurements . . . 44
Components . . . 44
Block Diagram . . . 44
Theory of Operation . . . 46
C.O. Module Features . . . 47
C.O. Module Exercises . . . 48

Cardiac Output #C10 (CCO) Module Concepts (CMS only) . . . 49
C.O. #C10 (CCO) Measurement (CMS only) . . . 49
Description . . . 49
Concepts . . . 49
Measurement Principle . . . 49
Measurement Acquisition . . . 49
. . . 50
Injectate Temperature and Volume . . . 51
C.O. #C10 (CCO) Module (CMS only) . . . 52
Description . . . 52
Measurements . . . 52
Components . . . 52
Block Diagram . . . 52
Theory of Operation . . . 54
C.O. #C10 (CCO) Module Features . . . 55

Arterial Oxygen Saturation/Plethysmography (SpO2/Pleth) Module Concepts . 56
SpO2 Measurement . . . 56
Description . . . 56
Concepts . . . 56
Measurement Principle . . . 57
Measurement Acquisition . . . 57
Output . . . 57
Criteria for Proper Measurement . . . 57
Plug-In Modules . . . 58
SpO2 Measurement Exercises . . . 59

SpO2/PLETH Module 60
Description 60
Measurements 60
Components 60
Block Diagram 60
Theory of Operation 62
SpO2/PLETH Module Features 63
SpO2/PLETH Module Exercises 65

Temperature (TEMP) Module Concepts 66
TEMP Measurement 66
Description 66
Concepts 66
Measurement Principle 66
Measurement Acquisition 66
Output 66
Criteria for Proper Measurement 66
Plug-In Modules 67
References 67
TEMP Measurement Exercises 68
TEMP Module 69
Description 69
Measurements 69
Components 69
Block Diagram 69
Theory of Operation 71
TEMP Module Features 71
TEMP Module Exercises. 72

Recorder Module Concepts 73
Recorder Module (M1116A) 73
Description 73
Block Diagram 73
Theory of Operation 75
Recorder Module Features 77
Recorder Module Exercises (M1116A) 79
Recorder Module (M1116B) 80
Description 80
Block Diagram 80
Theory of Operation 82
Recorder Module Features 83

Recorder Module Exercises (M1116B) 85

Data Transfer Module Concepts 86
Data Transfer Module 86
Description 86
Components 86
Block Diagram 86
Theory of Operation 88
Data Transfer Module Features 89
Data Transfer Module Exercises 90

Advanced Plug-In Modules 1
Introduction 1
Goals 1
Objectives 1
Topics 2

Invasive Blood Pressure Module Concepts 3
Invasive Blood Pressure Measurement 3
Description 3
Concepts 3
Measurement Principle 3
Measurement Acquisition 3
Measurement Output 4
Criteria for Proper Measurement 4
Plug-In Modules 4
Invasive Blood Pressure Measurement Exercises 5
Invasive Blood Pressure Module (M1006A) 6
Description 6
Measurements 6
Components 6
Block Diagram 6
Theory of Operation 8
PRESS M1006A Features 8
PRESS M1006A Module Exercises 10
Invasive Blood Pressure Module (M1006A/Option #C01) 11
Description 11
Measurements 11
Components 11
Block Diagram 11
Theory of Operation 13

PRESS M1006A/Option #C01 Module Features 14
PRESS M1006A/Option #C01 Module Exercises 15
Invasive Blood Pressure Module (M1006B) 16
Description 16
Measurements 16
Components 16
Block Diagram 16
Theory of Operation 18
PRESS M1006B Module Features 18
PRESS M1006B Module Exercises 19

CO2 Respiratory Gas Module Concepts 20
CO2 Respiratory Gas Measurement 20
Description 20
Concepts 20
Measurement Principle 20
Measurement Acquisition 20
Measurement Output 20
Criteria for Proper Measurement 21
Plug-In Modules 21
CO2 Respiratory Gas Measurement Exercises 22
CO2 Respiratory Gas Module (M1016A) 23
Description 23
Measurements 23
Components 23
Block Diagram 23
Theory of Operation 25
CO2 M1016A Features 25
CO2 M1016A Module Exercises 27
Sidestream CO2 Module (M1015A) 28
Description 28
Measurements 28
Components 28
Block Diagram 28
Theory of Operation 30
M1015A Sidestream CO2 Module Features 31
M1015A Sidestream Module Exercises 32

FIO2 Module Concepts (CMS only) 33
FIO2 Respiratory Measurement 33
Description 33

Concepts . . . 33
Measurement Principle . . . 33
Measurement Acquisition . . . 33
Measurement Output . . . 33
Criteria for Proper Measurement . . . 34
Plug-In Modules . . . 34
FIO2 Respiratory Measurement Exercises . . . 34
FIO2 Module (M1017A) . . . 35
Description . . . 35
Measurements . . . 35
Components . . . 35
Block Diagram . . . 35
Theory of Operation . . . 37
FIO2 M1017A Module Exercises . . . 39

Transcutaneous Gas ($tcpO_2$/$tcpCO_2$) Module Concepts . . . 40
tcpO2/tcpCO2 Measurement . . . 40
Description . . . 40
Concepts . . . 40
Measurement Principle . . . 40
Measurement Acquisition . . . 41
Measurement Output . . . 41
Criteria for Proper Measurement . . . 41
Plug-In Modules . . . 41
tcpO2/tcpCO2 Measurement Exercises . . . 42
tcpO2/tcpCO2 Module (M1018A) . . . 43
Description . . . 43
Measurements . . . 43
Calibration Algorithm . . . 43
Components . . . 45
Block Diagram . . . 45
Theory of Operation . . . 47
tcpO2/tcpCO2 M1018A Features . . . 48
tcpO2/tcpCO2 M1018A Module Exercises . . . 49

SvO2 Blood Gas Module Concepts (CMS only) . . . 50
SvO2 Blood Gas Measurement . . . 50
Description . . . 50
Concepts . . . 50
Measurement Principle . . . 50
Measurement Acquisition . . . 50

Measurement Output 50
Criteria for Proper Measurement 50
Plug-In Modules 50
SvO2 Blood Gas Measurement Exercises 51
SvO2 Module (M1021A) 52
Description 52
Measurements 52
Components 52
Block Diagram 52
Theory of Operation 54
SvO2 M1021A Features 55
SvO2 M1021A Module Exercises 57

Blood Analysis Module Concepts 58
Blood Analysis Measurement 58
Description 58
Concepts 58
Measurement Principle 58
Measurement Acquisition 60
Measurement Output 60
Negative Factors Affecting Proper Measurement 61
Blood Analysis Module (M1022A) 62
Description 62
Measurements 62
Components 62
Block Diagram 62
Theory of Operation 64
Blood Analysis Features 65
Blood Analysis Module - Software Update Requirements 66
Blood Analysis Module Exercises 67

VueLink Module Concepts 68
VueLink Module 68
Description 68
Measurements 68
Components 69
Block Diagram 69
Theory of Operation 71
M1032A VueLink Module Features 71
VueLink Module Exercises 73

EEG Module Concepts (CMS only) 74
EEG Measurement 74
Basics 74
EEG Channels 74
EEG Signal 74
Brain Waves 74
Frequency 75
Amplitude 77
Symmetry 77
Patterns 77
EEG Module 79
Description 79
Measurements 79
Components 80
Block Diagram 81
Theory of Operation 81
Electrode Application 83
EEG Module Features 85

BIS Module Concepts 86
BIS Measurement 86
Introduction 86
Depth of Anesthesia 86
The Bispectral Index (BIS) and Depth of Anesthesia 88
BIS Module 93
Description 93
Measurement 93
Components 93
Theory of Operation 94
BIS Module Features 95

CMS Patient Monitoring System 1
Introduction 1
Goals 1
Objectives 1
Topics 1
Definitions 2

CMS Patient Monitoring System Overview 4
Introduction 4
Objectives 4

Concepts 4
Topics 5
CMS Patient Monitoring System Description 6
Introduction 6
CMS Functionality 6
CMS Features 7
CMS Functions 7
CMS Patient Monitoring System Modules 8
CMS Patient Monitoring System Bus Structure 10
Introduction 10
Physical Backplane 11
Message Passing Bus 11
Local Bus 11
Utility Bus 11
Function Card Description Summary 12
Function Cards 13
Local Clusters 13
Card Placement 14
Minimum System Requirements 15
CMS Patient Monitoring System Power System 17
Introduction 17
Components 17
Theory of Operation 17
CMS Patient Monitoring System Hardware Configurations 19
Introduction 19
Application CPUs 19
Memory 19
Function Card Placement 20
Plug-in Parameter Modules 30
CMS Patient Monitoring System Software Configurations 31
Introduction 31
Standard Display 31
Selection Window 31
Task Window 31
Screen Messages 31
System Overview Exercises 32

CMS Patient Monitoring System Functional Modules 34
Introduction 34
Objectives 34

Concepts . . . 34
Topics . . . 35
Computer Module . . . 35
Introduction . . . 35
Front of the Computer Module . . . 35
Rear Connectors . . . 38
Integral Power Supply - Computer Module (M1046B) . . . 40
Integral Power Supply - Connectors and Controls . . . 40
Remote Power Supply (M1047A) . . . 41
Front Panel Controls - Remote Power Supply . . . 41
Remote Power Supply - Rear Controls and Connectors . . . 42
Display Module . . . 43
Introduction . . . 43
Display Models . . . 43
Front of Main Display . . . 43
Front Panel Controls and Connectors . . . 45
Rear of Main Display . . . 46
External Alarm Device Connectors and Controls . . . 47
CRT Display Rear Panel Connectors and Controls . . . 48
Switch-Mode Power Supply (SMPS) . . . 50
Remote Displays . . . 53
Control Panel . . . 53
Remote Keypad . . . 54
Introduction . . . 54
Connections . . . 54
Data Entry Keys . . . 54
Module Racks . . . 55
Introduction . . . 55
Types of Racks . . . 55
Integral Rack Connectors . . . 55
Satellite Module Rack Connectors . . . 56
Module Rack Theory of Operation . . . 56
Module Rack Block Diagram . . . 56
Plug-in Parameter Modules . . . 58
Types of Module . . . 58
Alarms . . . 59
Installing a Parameter Module . . . 59
“T” Parameter Module . . . 59
Connection to the Rack . . . 59
Connection to the Patient . . . 59

Precautions 59
CMS Patient Monitoring System Module Exercises 60

CMS Master Function Cards 63
Introduction 63
Objectives 63
Concepts 63
Topics 64
Master Card Overview 64
Introduction 64
Master Card Functions 65
Communication with the MPB 66
DC-to-DC Converter 67
Functional Block Diagram 67
Theory of Operation 68
Application CPU 69
Introduction 69
Components 69
Theory of Operation 70
Functional Block Diagram 71
LEDs 73
Summary of Functions 73
Configurable Processor Card 74
Introduction 74
Components 74
Theory of Operation 75
Functional Block Diagram 76
Daughter Card Block Diagram 76
CPC LEDs 77
Summary of CPC CPU Features 77
Monochrome Display Controller 78
Introduction 78
Connection to Display Module 78
Components 78
Theory of Operation 79
Functional Block Diagram 80
Summary of DSPC Card Features 81
Color Display Controller Cards 81
Introduction 81
Connections 81

CDSPC_CTRL Components 82
Theory of Operation 82
CDSPC_CTRL Functional Block Diagram 83
Summary of CDSPC Cards Features 83
Color Display Controller Card (New Version) 84
Introduction 84
Connections 84
CDSPC Components 84
Theory of Operation 85
CDSPC Functional Block Diagram 86
Summary of CDSPC Cards Features 86
Flatscreen Display Controller Card 87
Introduction 87
Connections 87
DSPC_FLAT Components 87
Theory of Operation 87
DSPC_FLAT Functional Block Diagram 88
Summary of DSPC_FLAT Card Features 88
DSPC_FLAT_ASIA Flatscreen Controller Card 89
Introduction 89
Connections 89
DSPC_FLAT_ASIA Components 89
Theory of Operation 89
Summary of Features 89
DSPC_XGA Display Controller Card 90
Introduction 90
Connections 90
DSPC_XGA Components 90
Theory of Operation 90
DSPC_XGA Functional Block Diagram 91
Summary of DSPC_XGA Card Features 91
Utility CPU 92
Introduction 92
Connections or Interfaces 92
Components 92
Theory of Operation 93
Functional Block Diagram 96
Utility Card LEDs 97
Summary of Utility CPU Features 97
RS232/RS422 Dual Interface Card 98

Introduction 98
Software Release Changes 98
Connections 98
Components 99
Theory of Operation 99
Functional Block Diagram 101
Summary of RS232/RS422 Features 102
HDLC Interface Card 102
Introduction 102
Components 102
Theory of Operation 102
Testing/Diagnostics 103
Functional Block Diagram 104
Summary of HDLC Features 104
Analog Interface Card 105
Introduction 105
Components 105
Theory of Operation 106
Functional Block Diagram 108
Summary of Analog Card Features 109

CMS Local Function Cards 110
Introduction 110
Objectives 110
Concepts 110
Topics 111
Local Card Overview 111
Introduction 111
Local Card Functions 111
EPROM 113
Introduction 113
Components 113
Theory of Operation 114
Functional Block Diagram 114
Summary of EPROM Features 115
SRAM 115
Introduction 115
Components 115
Theory of Operation 115
Functional Block Diagram 117

Summary of SRAM Features . . . 117
Color Display Video Card . . . 118
Introduction . . . 118
Connections . . . 118
CDSPC_VIDEO Components . . . 118
Theory of Operation . . . 119
CDSPC_VIDEO Functional Block Diagram . . . 121
Summary of CDSPC Cards Features . . . 122
Serial Distribution Network Interface . . . 122
Introduction . . . 122
Connections . . . 122
Components . . . 123
Theory of Operation . . . 123
Summary of SDN Features . . . 124
Functional Block Diagram . . . 125
Rack Interface . . . 126
Introduction . . . 126
Connections . . . 126
Components . . . 126
Theory of Operation . . . 126
Summary of Rack Interface Features . . . 127
Functional Block Diagram . . . 128
Aux Connector Card . . . 129
Introduction . . . 129
Connections . . . 129
Remote Switch Card . . . 129
Introduction . . . 129
Connections . . . 129

V24 and V26 Patient Monitors . . . 1
Introduction . . . 1
Goals . . . 1
Objectives . . . 1
Topics . . . 2
V24 and V26 Patient Monitors Description and Features . . . 3
Introduction . . . 3
Objectives . . . 3
Concepts . . . 3
Clinical Uses . . . 3
Product Releases . . . 3

V24 and V26 Patient Monitors Standard Package 3
Features 3
Mainframe 5
Rack Features 5
Parameter Modules 6
Philips Patient Care System 7
Data Management 7
Vital Signs Recording 7
Split Screen Capability 7
Clinical Calculation Set 7
Drug Calculator 7
Arrhythmia Detection 8
Anesthetic Gas Monitoring 8
Alarms 8
ST Segment Analysis 9
oxyCRG 9
Neonatal Event Review 9
Settings Transfer 9
V24 and V26 Patient Monitors Features Exercises 10
V24 and V26 Patient Monitors Interfaces 11
Introduction 11
Objectives 11
Concepts 11
Overview 11
V24 and V26 Patient Monitors Interfaces Exercises 13
V24 and V26 Patient Monitors User Controls and Connectors 14
Introduction 14
Objectives 14
Concepts 14
User Controls 14
Overview 14
Display 14
Front Panel Controls 15
The V24/V26 Front Panel Keys 15
V24/V26 User Controls Exercises 17
Connectors 18
Overview 18
Eight-slot Rack 18
Six-slot Rack 18
Connectors Exercises 19

V24 and V26 Patient Monitors Software Configurations 20
Introduction 20
Objectives 20
Concepts 20
Overview 20
Modules Partitioning 21
Application CPU Architecture 21
Utility CPU Architecture 21
Front End Microcontroller Architecture 21
V24/V26 Software Configurations Exercises. 22
V24 and V26 Patient Monitors Theory of Operation 23
Overview 23
V24, V24C, V26C Power Supply 25
V24CT/V26CT Power Supply 25
System Board 32
Application Subsystem 32
Utility Subsystem 32
Front End Interface Subsystem 32
Common Subsystem. 32
Front Panel Keyboard 32
Flat Panel Display. 33
Display Adapter Board. 33
3 Board Assembly. 33
Service Port Connectors 33
Six-slot Rack Eight-slot Rack 33
V24/V26 Theory of Operation Exercises 33

Philips Monitoring Network (SDN) 1
Introduction 1
Goals 1
Objectives 1
Topics. 2
Defining the Philips Monitoring Network (SDN) 2
Philips Monitoring Network (SDN) Components 3
Philips Care Hub (SCC) 4
Philips Monitoring Network (SDN) Interface Circuitry 4
Wall Boxes and Face Plates 4
Branch Cables. 4
Local Distribution Cables (LDC) 4
How the Philips Monitoring Network (SDN) Works. 4

Defining the Inter-SDN Gateway. 8
Defining the Inter-SDN Gateway Exercises 11

Introduction

The Purpose of This Book

Philips Medical Systems' *CMS Patient Monitoring System* & *V24 and V26 Patient Monitors Concepts Guide* is a companion volume to the Service Guides of both the CMS and V24/V26 patient monitors. This volume contains conceptual information and technical details on both patient monitoring families.

The purpose of this book is to provide a conceptual foundation for the monitoring systems in order to support effective troubleshooting and repair. The book is not intended to be a comprehensive, in-depth explanation of the product architecture or technical implementation. Rather, it was developed to offer enough information on the functions and operations of the monitoring systems so that engineers who repair them will be able to better understand how they work.

The book provides a bird's-eye-view of the product family in the context of the clinical settings and measurements for which they are used. It covers the physiological measurements that the products were designed to provide, the modules that acquire those measurements, the three systems that use those modules, and the network that ties all of the pieces together into an integrated whole.

Who Should Use This Book

If you are a biomedical engineer or a technician responsible for troubleshooting, repairing, and maintaining Philips' patient monitoring systems, this book was designed for you. If you are new to Philips' product line or monitoring systems, you may find it helpful as an orientation to the equipment. If you have been working on the systems for awhile and now want further details on how they work, you are likely to find much of the information you need here. If you want to learn about patient measurements and the principles by which they are derived, this is a good place to start.

What The Book Contains

Intro

The CMS & V24/V26 and their families of products are powerful, flexible patient monitoring systems that provide a wide range of data acquisition and processing functions for all types of patients, in both critical care and routine care settings. Although these patient monitors are highly reliable and easy to use, its high degree of flexibility and functionality may seem daunting to users and technicians who do not work with it on a regular basis. The information in this book will, we hope, make the systems easier to understand.

How the Book is Structured

The book contains five chapters, each of which may be used independently of the others.

Chapters in This Book

Chapter Title	Description
Basic Plug-In Modules	The measurements taken by the basic set of plug-in parameter modules used by Philips' patient monitoring systems, and the functional descriptions of the modules themselves.
Advanced Plug-In Modules	The measurements taken by the advanced set of modules, along with the functional descriptions of the modules.
CMS	A functional description of the CMS, including its components and operations.
V24 and V26 Patient Monitors	A functional description of the V24/V26, including its components and operations.
Philips Patient Network	An overview of the Philips Patient Network (SDN), including its major components, functions, and the services it provides.

How the Content Is Organized

The flow of information proceeds from the patient inward toward the system. The chapters begin with the measurements that are taken from patients and the plug-in modules that are designed to acquire and process those data. The module information is organized based on the technical complexity of the device, not on the characteristics of the measurements. The first set of modules, from a technical perspective, are simpler in operation. The next set of modules performs more complex data processing operations.

Following the plug-in modules are chapters that cover the monitoring systems with which the modules can be used. These are the CMS, Anesthesia CMS (ACMS) the Neonatal CMS (NCMS) and the V24/V26.
The CMS is Philips' premier modular monitoring system with full functionality and the ability to use all of the modules. The V24 and V26 are designed to be used with patients who are being monitored in a Critical Care environment. The V24CT/V26CT can also be used during patient transport between units. It can use most, but not all, of the plug-in modules of the Philips patient monitoring system.

The final chapter covers the Philips monitoring network (SDN), also called Philips patient care system, which enables the monitoring systems to be connected to a central station. With Philips monitoring network (SDN), central monitoring stations can be connected to bedside monitors, external computers, and measurement instruments to provide clinical staff with the configuration that meets their needs.

How to Use This Book

Learning and Reference

The book was designed as a combination self-paced training course and reference manual. While it does not cover every aspect of the monitoring systems in detail, it covers the functional descriptions that are provided in the Service Manuals for the individual systems. To help you plan and assess your learning, it provides:

- goals for each chapter
- learning objectives for each section within a chapter
- highlights of important concepts, as well as topic lists at the beginning of each section
- practice exercises within each chapter
- a final self-assessment test at the end of the book

Choose Your Approach

Your approach to this book will likely depend on your personal preference and job needs. You can use the book as a self-paced training course, a reference document, or both. Although the book has a logical information flow, the chapters are independent units that do not have to be read in any particular order. Here are some suggested approaches:

- If you are unfamiliar with the products and would like to use the book as a training document, start at the beginning and work your way through at your own pace, using the learning aids provided.
- If you already have some knowledge of the systems and want to identify the areas in which you need to learn more, you may want to start by taking the test at the end of the book. The questions are grouped to correspond with specific sections of the book. By identifying the questions you were not able to answer correctly, you can focus your learning on only those areas. You'll also have a better idea of how much you already know. Then, take the test again at the end to reinforce your knowledge.
- You may want to use the book as a reference as you study the troubleshooting guides for the systems, or as a pre-course to help prepare yourself for troubleshooting.
- If you already know a lot about the hardware and want to focus on the measurement principles exclusively, you may want to pull out those sections and put them together in whatever order would be useful to you.

Chapter 1 Basic Plug-In Modules

Introduction

This chapter covers the basic set of plug-in parameter modules used by the patient monitoring systems and the measurement principles on which they are based. The next chapter covers the more advanced modules and their measurements.
The categorization of basic and advanced modules is based on the complexity of their data-processing functions, rather than on the ease or difficulty of taking the measurements. Engineers who maintain and repair the equipment may want to become familiar with the basic modules before moving on to the more complex ones.

Goals

After successfully completing this chapter, you should be able to:

- Describe the physiologic measurements that can be acquired and processed by Philips' basic plug-in parameter modules.
- Explain how Philips' plug-in modules acquire and process physiologic measurements.

Objectives

In order to meet the chapter's goals, you should be able to:

- Define each of the physiologic measurements.
- State the principle by which each measurement is derived.
- Recognize the forms in which the data for each measurement are represented.
- Identify the criteria and influencing factors related to the proper acquisition of the measurement.
- Describe the method, components, and mechanisms by which the measurement's electrical signals are processed by the corresponding plug-in module.
- Identify and describe the features of the module.

Topics

This chapter contains the following topics:

Chapter Topics

Measurements and Modules	Page
ECG Measurement	1-3
ECG Module	1-13
RESP Measurement	1-19
ECG/RESP Module	1-23
NBP Measurement	1-30
NBP Modules	1-34
C.O. Measurement	1-40
C.O. Module	1-44
C.O. #C10 (CCO) Measurement (CMS only)	1-49
C.O. #C10 (CCO) Module (CMS only)	1-52
SpO2 Measurement	1-56
SpO2/PLETH Module	1-60
TEMP Measurement	1-66
TEMP Module	1-69
Recorder Module (M1116A)	1-73
Recorder Module (M1116B)	1-80
Data Transfer Module	1-86

Electrocardiogram/Respirogram (ECG/RESP) Module Concepts

ECG Measurement

Description

The skin surface electrocardiogram (ECG) measures the electrical activity of the patient's heart, or myocardium. This information indicates the condition of the heart's electrical conduction system.

ECG is also referred to as EKG, the abbreviation for the German spelling of the term.

Concepts

ECG concepts important to electrocardiogram measurement are:

- **Lead -** A specific electrode or array of electrodes used to record changes in electrical potential created by activity of an organ, such as the heart.
- **QRS complex -** The portion of an ECG waveform that represents the depolarization of the cardiac ventricles.
- **ST segment -** The portion of an ECG waveform that represents the time period between the end of ventricular depolarization and the start of ventricular repolarization.
- **Pace pulse -** On an ECG waveform, the marks indicating the initiation of cardiac depolarization and contraction generated by an artificial pacemaker.

Measurement Principle

The electrical cells of the heart generate, conduct, and coordinate electrical impulses that cause the heart's mechanical cells to contract. As these impulses move through the various parts of the heart's conduction system, small electrical currents also move toward the body's surface. An ECG measures the heart's electrical activity as the heart contracts and relaxes by recording the electrical signals on the patient's skin. The measurement represents the changing electrical potentials and their progression through the heart; the ECG records data on both the direction of electrical activity and its magnitude.

The electrical signals are detected by electrodes placed on various areas of the patient's trunk and limbs. The information carried by the signals varies according to where and how the electrodes are placed.

Measurement Acquisition

An ECG is recorded using lead cables connected to a monitoring device. ECG leads are single electrodes, or arrays of electrodes, placed at specific anatomical positions that detect the electrical voltage of a specific cardiac vector. Each lead monitors the heart's electrical activity from a different perspective. Unipolar leads detect signals moving from the heart to the skin's surface; bipolar leads detect the surface electrical activity moving from one electrode to another. The EASI 12-lead ECG uses a special lead positioning that detects electrical activity, which does not correspond directly to

the standard ECG vectors, but from which all 12 of the standard vectors can be derived.

Lead cable sets are available with various numbers of lead wires; common types are three, five, and twelve lead sets. The end of each wire is attached to an electrode and is color-coded to facilitate anatomical placement. Electrodes can be placed in many different arrangements, depending on factors such as clinical application, type of patient, and suspected diagnosis.

Limb Leads

Three bipolar limb leads are called *leads I, II,* and *III*. Electrodes are placed on the patient's right arm, left arm, and left leg, forming a pattern known as *Einthoven's triangle*. For convenience, the electrodes can also be placed on the patient's trunk near the shoulders and hip.

The unipolar leads are called *aVR, aVL, and aVF;* they can be monitored by the same three electrodes. When selected on the monitor, these leads measure the current from the heart out to the specified limb.

Figure 1-1 shows the electrode placements and direction of the signals for limb leads. (European colors in brackets)

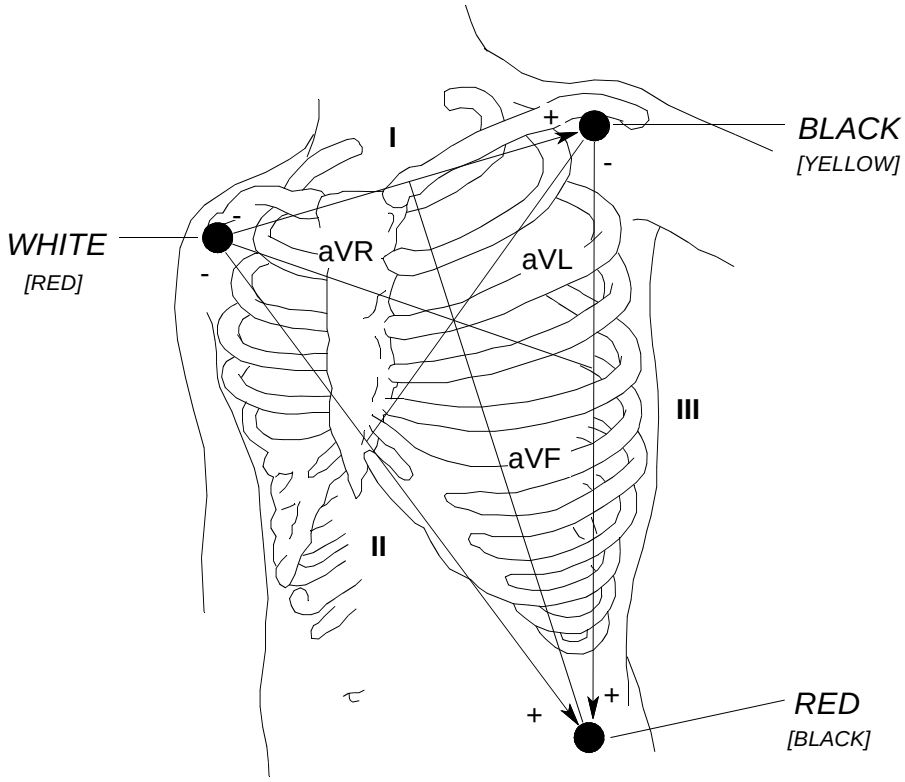


Figure 1-1 Electrode Placement for Limb Leads

Chest Leads Chest leads, also called *precordial* leads, are unipolar. Leads labelled V with a number or letter designation can be placed around the entire circumference of the chest, as well as the back. The most common clinical objective in matching V leads is ischemia detection. Figure 1-2 shows an example of the placement of these leads.

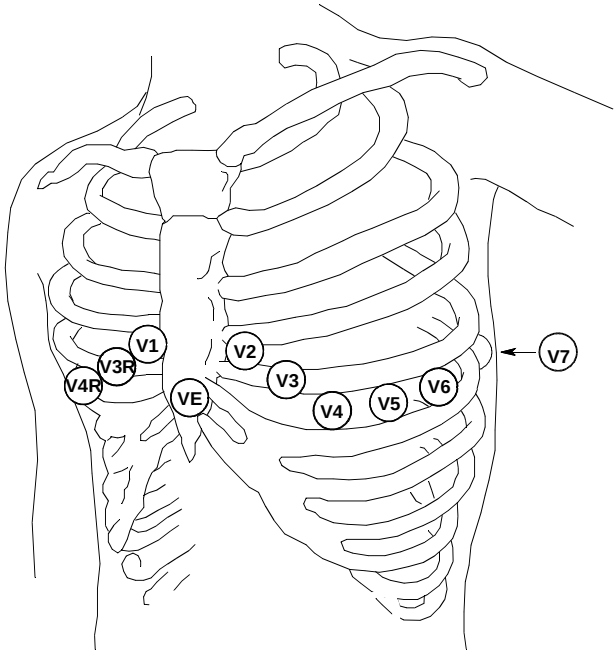


Figure 1-2 Electrode Placement for Chest Leads

Modified Chest Lead (MCL_1)

MCL_1 is a bipolar chest lead in which two electrodes are placed over the chest as shown in Figure 1-3. Other modified leads are also commonly used. The position and index of the chest electrode corresponds to the V-positions in Figure 1-2. (European colors in brackets).

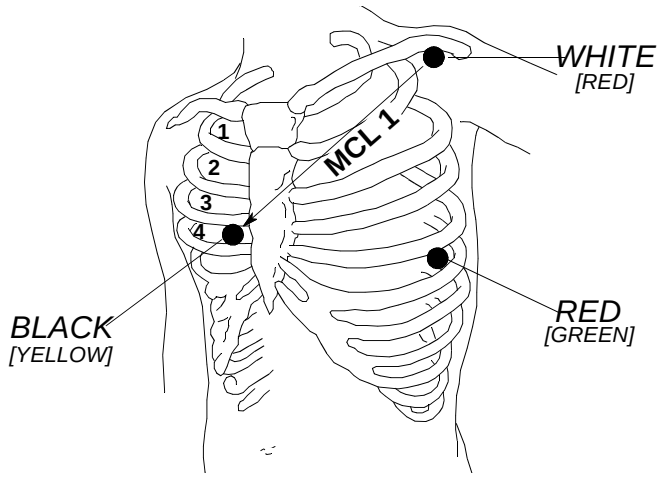


Figure 1-3 Modified Chest Lead (MCL1)

Five-Electrode Placements

Electrodes for five-lead sets can be placed in various positions. One arrangement is shown in Figure 1-4. The right leg (RL) lead serves as a ground. (European colors in brackets).

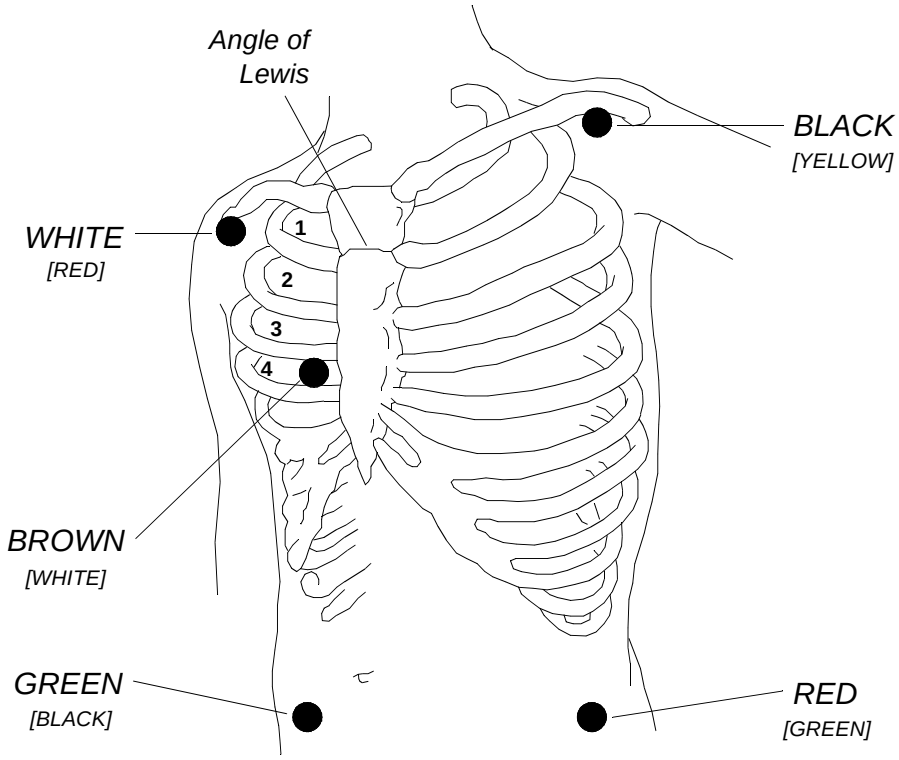


Figure 1-4 Five Electrode Placement

For EASI 12-lead ECG derivation, the leads should be placed as shown in Figure 1-5. (European colors in brackets).

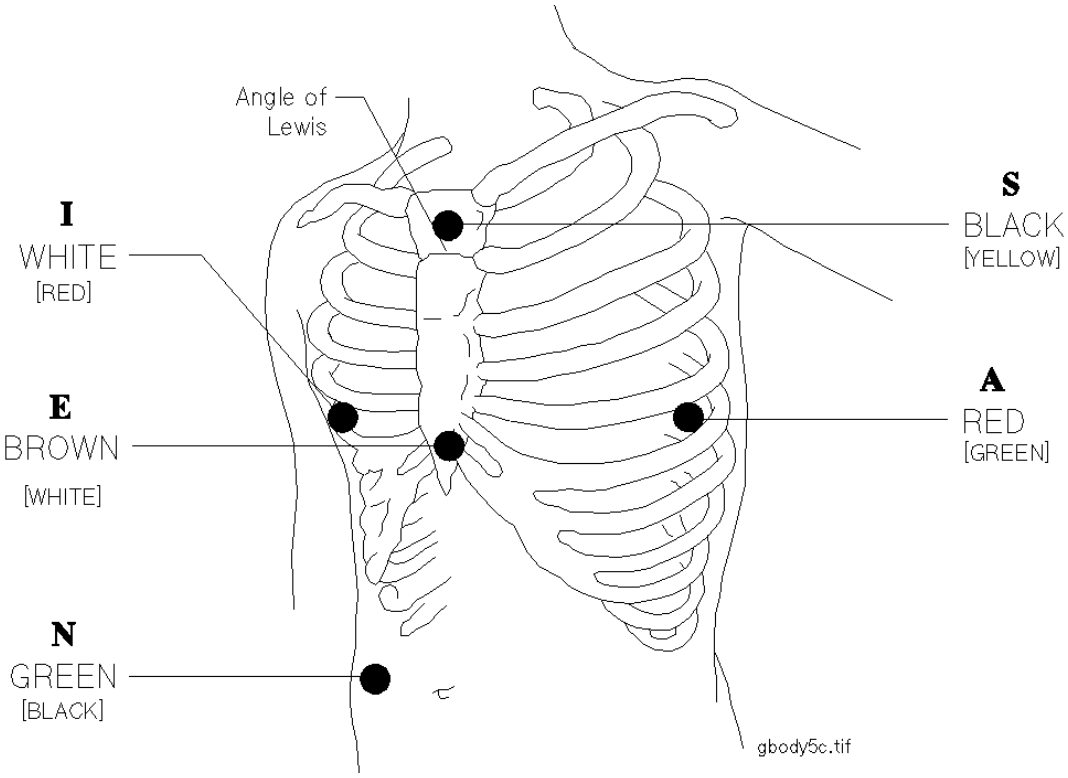


Figure 1-5 EASI 12-lead Electrode Placement

Output

ECG signals are depicted as continuous waveforms that show real-time changes in lead voltages. The ECG shows the cycles of depolarization and repolarization of various parts of the heart, enabling practitioners to localize cardiac pathology. It interprets the electrical potentials as positive or negative, and plots them on a graph as upward and downward deflections from a baseline.

ECG Waveforms

Many variations of the basic waveform are possible, depending on which leads are being measured and the condition of the patient's heart. Figure 1-6 shows the basic ECG wave.

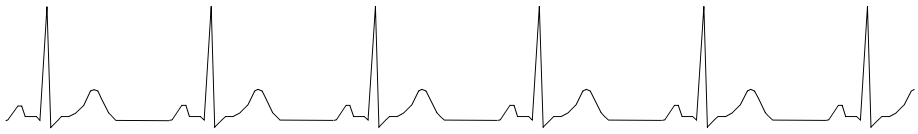
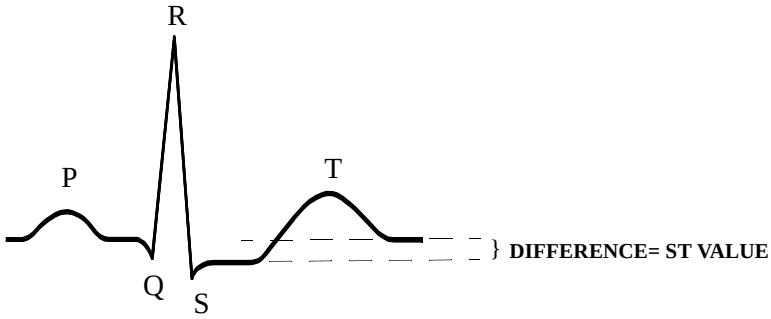


Figure 1-6 Basic ECG Waveform

The parts of a wave are labeled, *P, QRS,* and *T,* as shown in Figure 1-7. For patients with artificial pacemakers, small dashes called pace pulses appear at the beginning of each wave. The QRS complex may actually be composed of only Q and R waves, only R and S waves, or only an R wave.



Normal QRS Complex

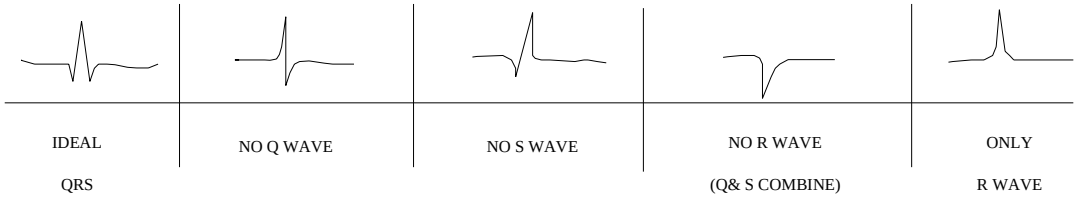


Figure 1-7 The QRS Complex

ST Segment

The ST segment is the part of the waveform between the S and T waves. This part of the waveform plays a critical role in diagnosing cardiac abnormalities. ST segment analysis is an important function in patient monitoring systems. An elevated or depressed ST segment can indicate a serious condition.

Criteria for Proper Measurement

Factors affecting accurate measurement of ECG are:

- Proper placement of electrodes. In order to record the strongest signals from the appropriate angles, electrodes must be placed precisely. Failure to do so may result in erroneous readings.
- Good skin contact. Because ECG signals are small, low voltages (millivolts), the electrodes must make good contact with the patient's skin in order to get an accurate reading. Good contact requires proper skin preparation and periodic electrode replacement.
- Proper selection of leads. Leads must be selected with the correct cable sets to measure the appropriate electrical activity. Selecting the wrong leads could result in misdiagnosis of the heart's condition.
- Elimination of external interference. A patient's movements or bones can interfere with the signal, as can pacemaker activity and electrical interference from electrosurgical units (ESU). In the OR application, for example, electrodes should be placed equidistant from the surgical site to improve the ESU suppression. Other extraneous sources of electrical interference can be electrical appliances around the patient.

Plug-In Modules

Two of Philips' plug-in modules can measure ECG: the ECG Module (M1001A/B) and the ECG/RESP Module (M1002A/B). Check the documentation for the system being used for determination of module usability.

ECG Measurements Exercises

1. An ECG measures both the magnitude and _____ of the heart's electrical signals.

2. Specific electrodes that measure specific cardiac vectors are called_____.

3. The right leg electrode serves as a _____.

4. The part of the ECG waveform that plays a critical role in diagnosing serious heart conditions is the:
   a. P wave
   b. QRS complex
   c. ST segment

Answers
1. direction
2. leads
3. ground
4. c

ECG Module

Description

The M1001A/B ECG Module is a three-channel electrocardiogram measurement parameter unit. It is designed to be used with adult, neonatal, or pediatric patients in Critical Care environments.

The M1002A/B ECG/RESP Module possesses the same ECG functionality as the ECG Module and adds respirograph functions as well.

Measurements

The ECG produces up to 3 continuous real-time waveforms of the patient's cardiac electrical activity. It also generates numerics for the average heart rate (HR), derived from either the ECG or a remote arrhythmia computer.

Components

The following components carry out the major signal processing functions within the module.

Table 1-1 Major ECG Module Components

Component	Function
Input Protection Network and ESU Filter	Protects the input amplifiers from defibrillation and high frequency interference signals.
Lead Selection Switches	Selects channels 1 and 2 for patient leads. (with EASI also channel 3)
Right Leg Drive	Minimizes interference from the 50/60Hz power line.
Highpass and Lowpass Filters	Allow independent selection of diagnostic, monitoring, or filter bandwidths for each channel.
Test Signal	Generates a calibration voltage on each channel and tests the circuitry of the module.
Pace Pulse Detector	Detects pace pulses for channels 1and 2.

Block Diagram

Figure 1-8 shows the module's logical structure.

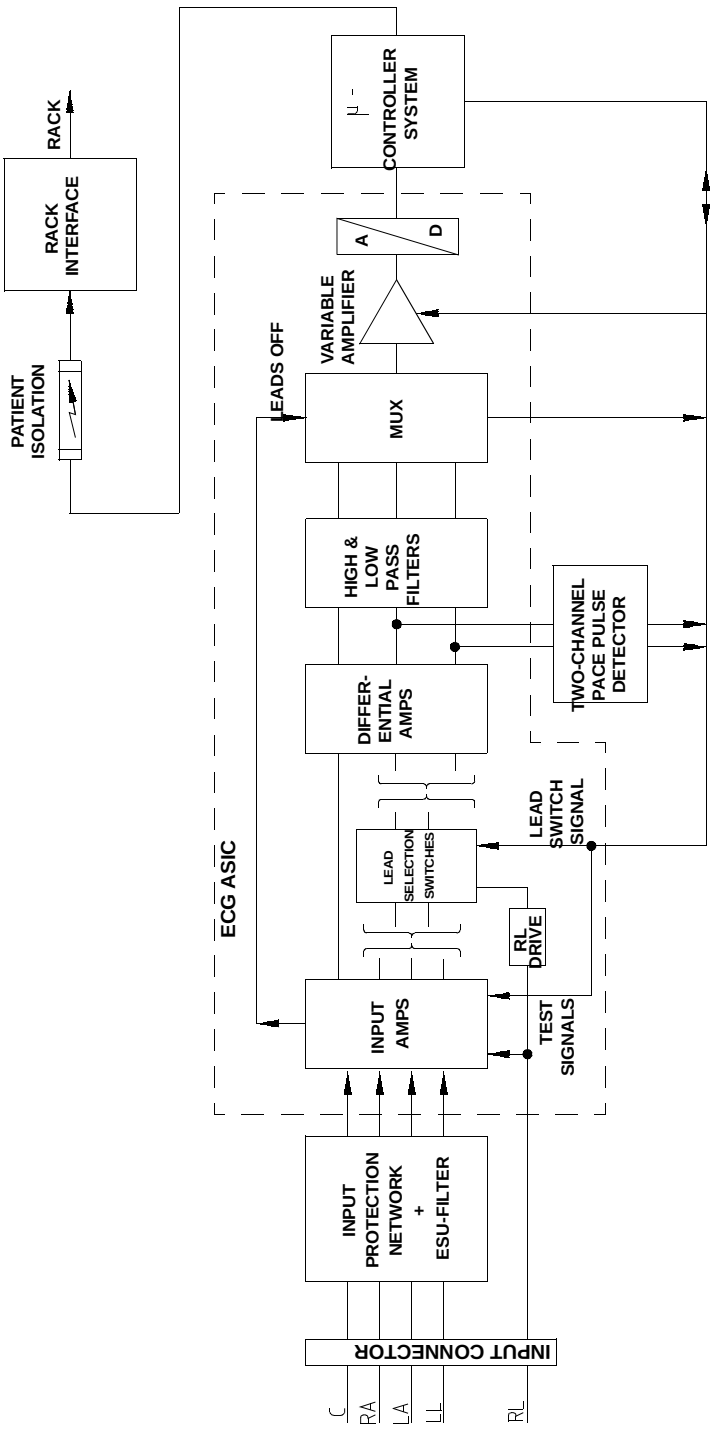


Figure 1-8 M1001A ECG Module Block Diagram

Theory of Operation (M1001A/M1002A)

As ECG signals pass from the patient to the monitor, they progress through stages corresponding to the four logical sections of the module, as shown in the block diagram of Figure 1-8. Module-related faults can generally be isolated to one of the four stages.

1 Signals are received through patient electrodes and lead cables by the input connector.

2 The input protection network and ESU Filter eliminate extraneous signals.

3 The signals are processed by two circuits: the ECG Application Specific Integrated Circuit (ECG ASIC) and the Pace Pulse Detector (PPD ASIC). At this point, the analog signals from each lead are selected, amplified, filtered, and converted to digital form. During the process, the output of each input amplifier is checked for a leads-off electrode condition, so that any detached electrode can be identified. The leads for channels 1 and 2 are selected using two identical lead selection circuits; channel 3 always carries the chest lead. The signals from the three channels are summed in the differential amplifiers.

To prevent interference from the 50/60Hz power line, the common mode signal derived from behind the lead selectors is used to drive the right leg drive amplifier. The output from the amplifier is then returned to the patient via the RL electrode. The PPD checks channels 1 and 2 to detect pulses from a pacemaker for display or cardiotach rejection. The high and low pass filters allow the independent selection of diagnostic, monitoring, or filter bandwidths for each channel.

For calibration purposes a 1mV calibration signal will be generated on each of the channels, in front of the filtering circuitry. The complete module can be tested (from in front of the first amplifier) on user request. That means switching the patients lead off, selecting lead V for all channels, and feeding in a test signal.

4 The microprocessor, which connects to the patient isolators and rack interface through a front-end link, passes control signals for lead selection and pulse detection from the monitor to the module components through the control lines. It extracts the requested physiologic features from the cardiac signals and passes them on to the monitor. Meanwhile, all needed voltage for the module’s operation is provided by the internal power supply, which receives 78 MHz and 60 V DC through the rack interface.

5 In the case of EASI 12-lead ECG, the signal is processed to derive any 3 of the standard 12 vectors.

ECG Module Features

Figure 1-9 shows the user controls and connector for the ECG Module. The parts are described following the figure.

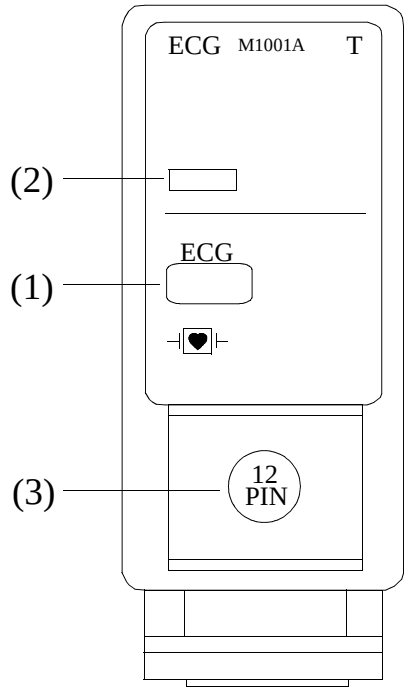


Figure 1-9 ECG Module Controls and Connectors

User Controls

1 **Setup Key**—A single-press key used to enter the ECG setup screen.

2 **Setup Indicator—**A green LED, lit when the ECG setup screen is activated.

Connectors

3 The standard 12-pin connector will accept either a 3-lead or 5-lead ECG cable. For EASI a 5-lead cable is required.

Waveforms

The size of the waveforms can be adjusted automatically or manually.

Four configuration settings are possible to control the size and position of the waveform.

Table 1-2 Waveform Settings

Setting	Description
Autoadjust	The wave size is automatically adjusted to fit inside the channel. The position of the wave is optimized so that the middle of the wave occupies the middle of the channel, unless ST monitoring is switched on.
Autosize	The wave size is automatically adjusted to fit inside the channel. This setting adjusts the amplitude of the wave but not its offset.
Gain x 1	The amplitude of the wave is magnified by 1000.
Gain x 2	The amplitude of the wave is magnified by 2000.

QRS Detection

Because the QRS complex is the most prominent part of the ECG waveform, it is used by clinicians to determine the strongest ECG signals.

QRS detection can occur in auto or manual mode. In auto mode, QRS complexes are detected automatically. In manual mode, the QRS detection level appears on the screen as a horizontal line across the ECG wave.

Paced vs. Non-Paced Mode

In non-paced mode, no pace pulses are expected and no pace pulse rejection occurs. In paced mode, pace pulses are annotated with a small dash on the screen.

ST Segment Analysis

ST segment analysis is an optional feature. ST segment measurements can be recorded on up to three channels and three leads of a patient's ECG. The measurements are shown as numerics on the standard display, graphically in the ST analysis task window, and as part of patient vital signs and trend graphs. They can be recorded with reference beats at the bedside, or without beats at a central monitor or recorder.

Up to 242 sets of real-time algorithm outputs can be graphed, stored, and recalled, each with up to three channels of data. All stored waves are cleared after a discharge procedure when the monitor is turned off for more than three hours, or when monitoring mode is reset.

Safety

To ensure the safety of the patient, the patient-applied parts are isolated from ground by optical isolators and a transformer. The module is also encapsulated in plastic.

ECG Module Exercises

1. The ECG generates numerics for which physiologic measurement?
   a. pulse
   b. pace pulses
   c. heart rate

2. Which ECG Module component prevents interference from the 50/60 Hz power line?

   a. Input protection network
   b. Right leg drive
   c. Highpass and lowpass filters

3. Which channels does the PPD check for pace pulses?

   a. Channels 1 and 2
   b. Channels 2 and 3
   c. Channels 1, 2, and 3

4. The number of ST segment measurements that can be stored and retrieved is_____.

5. For EASI 12-Lead Monitoring you need
   a. a 3-lead or a 5-lead cable
   b. a 5-lead cable.

6. With a standard lead set and five-electrode cable set, the leads that can be monitored are:
   a. 3 limb or chest leads on Channels 1, 2, and 3
   b. 3 limb or chest leads on Channels 1 and 2, and 1 chest lead on Channel 3
   c. 7 limb or chest leads on both Channel 1 and Channel 2, and 1 chest lead on Channel 3

7. With an EASI lead set, the leads that can be monitored are:
   a. 3 limb or chest leads on Channels 1, 2, and 3
   b. any lead out of 12 for all 3 channels
   c. 7 limb or chest leads on both Channel 1 and Channel 2, and 1 chest lead on Channel 3

Answers
1. c
2. b
3. a
4. 242
5. b
6. a
7. b

RESP Measurement

Description

A respirogram is a recording of respiratory activity that indicates the strength and efficiency of a patient's respiratory (pulmonary) muscles. The measurement can be accomplished using various techniques; the method employed by Philips' patient monitoring devices is the impedance method.

Concepts

Respiration is the metabolic process by which the body obtains oxygen, expels carbon dioxide, and regulates its acid-base (pH) balance.This process is carried out by a respiratory system composed of the lungs, the respiratory muscles (notably the diaphragm and intercostal muscles), and the organs that carry gas into and out of the lungs. Respiratory monitoring techniques measure either the nature of the gas exchange within the lungs, or the efficiency of the pulmonary muscles. A respirogram is concerned with the latter.

An important concept for respirogram monitoring is:

- **Respiratory rate -** The timing and rhythm of inspiration and exhalation.

If any of these measurements is above or below the normal range, other respiratory monitoring techniques may be needed to assess the patient's overall respiratory condition.

Measurement Principle

Within the thorax (chest), the lungs are surrounded by a moist pleural membrane, which produces a lubricating fluid that enables the lungs to move easily during respiration. This fluid, along with the change in volume of air, allows the measurement of electrical impedance when the lungs expand and contract.

A respirogram measures the change in electrical impedance between two electrodes placed on the patient's skin as the patient breathes in and out. By using a modulation technique for measuring the impedance, with a carrier frequency that is far outside the ECG bandwidth, the same electrodes that are used for the ECG measurement can be used for respiration. Although the ECG and RESP signals are obtained using the same electrode set, the measurement principles are fundamentally different.

Measurement Acquisition

RESP is measured by placing two electrodes, right arm (RA) and left leg (LL), on the patient's skin as shown in Figure 1-10. For EASI 12-Lead ECG the positions are different (see Figure 1-5).

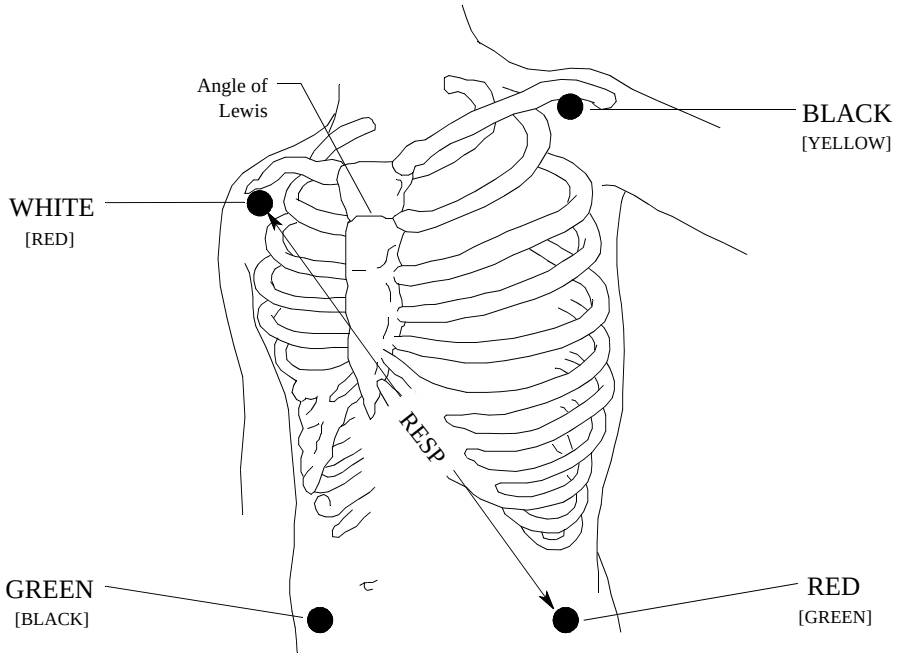


Figure 1-10 Electrode Placements for RESP

The impedance measurement contains several signals:

- The basic impedance of the thorax.
- The change in impedance caused by breathing.
- The change in impedance caused by cardiac activity.

The impedance change caused by breathing activity is extracted from the basic impedance and displayed as a respiration wave. Impedance changes caused by cardiac activity are discarded and are not included in the respiration rate.

Output

RESP signals are depicted as continuous waveforms that show real-time changes in impedance. Both the respiratory rate and heart rate are shown as numeric values.

Criteria for Proper Measurement

Factors affecting accurate measurement of RESP are:

- Proper placement of electrodes, in order to optimize the measurement of impedance changes. Since ECG waveforms may require more precise placement, ECG waveform results may have to be considered when repositioning leads and electrodes to optimize respiratory wave size.
- Good skin contact, to maintain a good signal.
- Elimination of external interference. A patient's movements, bones, or organs can interfere with the signal, as can pacemaker activity and electrical interference from electrosurgical units (ESU). Respirogram monitoring is not recommended for active patients because false alarms may occur. Normal cardiac activity is filtered out. However, artifacts from pulsating blood can interfere if the liver or cardiac ventricles are between the electrodes.

Plug-In Modules

The ECG/RESP Module (M1002A/B) provides respirogram and electrocardiogram functions. It can be used with most of the monitoring systems in the Philips patient monitoring family. Check the documentation for the system being used for determination of module usability.

References

Ahrens, Tom. Respiratory Monitoring in Critical Care, in *AACN Clinical Issues in Critical Care Nursing*. [For bibliography: Susan Osguthorpe, ed. Philadelphia, JB Lippincott, 1993.]

Philips Part No. 78834-90090 "Neonatal Monitoring: The ABCs of ECG and Resp."

Philips Part No. 5954-2304 Application Note

RESP Measurement Exercises

1. Respiratory monitoring generally measures two types of pulmonary functioning: the effectiveness of _____ and efficiency of _____.

2. RESP uses a _____ technique that allows electrical impedance to be measured using ECG electrodes.

3. RESP uses ECG electrodes placed in which positions:

   a. Left arm and right arm
   b. Left arm and right leg
   c. Right arm and left leg

4. The data displayed in a respiration wave are:

   a. Impedance change from breathing activity
   b. Respiratory rate
   c. Heart rate, as a numeric
   d. all of the above

Answers

1. Gas exchange, pulmonary muscles
2. Modulation
3. c
4. d

ECG/RESP Module

Description

The M1002A ECG/RESP Module is a three-channel electrocardiogram and respiration measurement parameter unit. It is designed to be used with adult, neonatal, or pediatric patients in an ICU environment.

The module possesses the same ECG functionality as the M1001A and adds respirogram functions as well.

Measurements

The ECG/RESP Module produces continuous real-time waveforms for both cardiac and pulmonary electrical activity. It also generates numerics for the average heart rate (HR), derived from either the ECG or a remote arrhythmia computer, and for the respiration rate (RR).

Components

The following components carry out the major signal processing functions within the module.

Table 1-3 Major ECG Components of ECG/RESP Module

ECG Component	Function
Input Protection Network and ESU filter	Protects the input amplifiers from defibrillation and high frequency interference signals.
Lead Selection Switches	Selects channels 1 and 2 for patient leads.
Right Leg Drive	Prevents interference from the 50/60Hz power line.
Highpass and Lowpass Filters	Allow the independent selection of diagnostic, monitoring, or filter bandwidths for each channel.
Test Signal	Generates a calibration voltage on each channel and tests the circuitry for the module.
Pace Pulse Detector	Detects pace pulses for channels 1and 2.

Table 1-4 Major RESP Components of ECG/RESP

RESP Component	Function
Input Protection Network and ESU filter	Protects the input amplifiers from defibrillation and high frequency interference signals.
Measurement Bridge	Detects and modulates the RA and LL ECG signals with a 39 kHz sine wave. Generates a calibration and test signal.
Synchronous Demodulator	Demodulates the output from the input amplifier.
Impedance Subtracter and Digital-to-Analog Converter	Subtracts the basic thoracic impedance from the signal and converts it to digital form.

Block Diagram

Figure 1-11 shows the ECG/RESP module's logical structure.

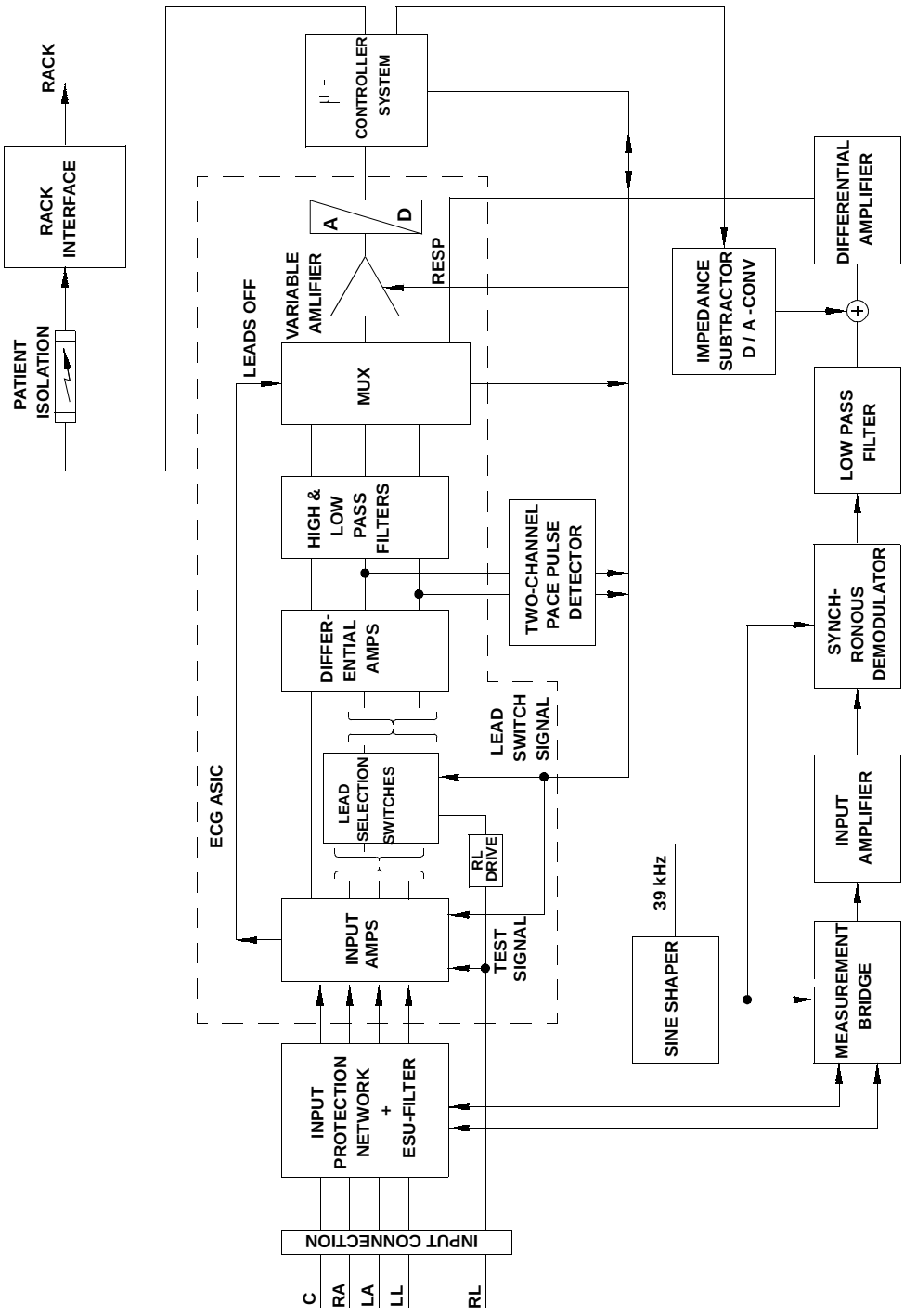


Figure 1-11 M1002A/B ECG/RESP Module Block Diagram

Theory of Operation

As ECG and RESP signals pass from the patient to the monitor, they progress through stages corresponding to the four logical sections of the module, as shown in the block diagram. Module-related faults can generally be isolated to one of the four stages.

1 Signals are received through patient electrodes and lead cables by the input connector.

2 The input protection network and ESU filter eliminate extraneous signals.

3 **ECG:** The signals are processed by two circuits: the ECG Application Specific Integrated Circuit (ECG ASIC) and the Pace Pulse Detector (PPD ASIC). At this point, the analog signals from each lead are selected, amplified, filtered, and converted to digital form. During the process, the output of each input amplifier is checked for a leads-off electrode condition, so that any individual lead whose electrode has fallen off can be identified. The leads for channels 1 and 2 are selected using two identical lead selection circuits; channel 3 always carries the chest lead. The signals from the three channels are summed in the differential amplifiers.

To prevent interference from the 50/60Hz power line, the common mode signal derived from behind the lead selectors is used to drive the right leg drive amplifier. The output from the amplifier is then returned to the patient via the RL electrode. The PPD checks for pace pulses on channels 1 and 2 for cardiotach rejection or marking of the display. The high and low pass filters allow the independent selection of diagnostic, monitoring, or filter bandwidths for each channel.

For calibration, a 1mV calibration signal is generated on each channel. This is done by a bandgap voltage reference from a precision voltage divider in front of the filtering circuitry. The complete module can be tested on user request.

RESP: The measurement bridge, driven by a 39kHz sine wave, detects and excites the ECG signals from the RA and LL lead paths behind the Input Protection Network. The modulated output is amplified by the differential input amplifier, demodulated by the synchronous demodulator, and input to a low-pass filter. The impedance subtracter subtracts the basic thoracic impedance to derive the respiration wave signal. The signal is then multiplexed with the ECG signals, amplified, and converted to digital for use by the microprocessor.

For calibration and testing purposes, a 1 ohm test signal is generated by the bridge circuitry.

4 The microprocessor, which connects to the patient isolators and rack interface through a front-end link, passes control signals for lead selection and pulse detection from the monitor to the module components through the control lines. It extracts the requested physiologic features from the cardiac signals and passes them on to the monitor. Meanwhile, all needed voltage for the module’s operation is provided by the internal power supply, which receives 78 MHz and 60 V DC through the rack interface.

ECG/RESP Module Features

Figure 1-12 shows the user controls and connector for the ECG/RESP Module. The parts are described following the figure.

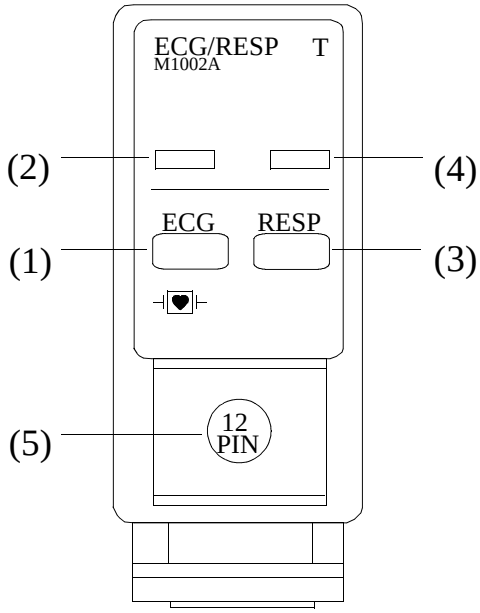


Figure 1-12 ECG/RESP Module Controls and Connectors

User Controls

1 **ECG Setup Key**—A single-press key used to enter the ECG setup screen.

2 **ECG Setup Indicator—**A green LED, lit when the ECG setup screen is activated.

3 **RESP Setup Key**—A single-press key used to enter the Respiration setup screen.

4 **RESP Setup Indicator**—A green LED, lit when the Respiration setup screen is activated.

Connectors

5 The standard 12-pin connector will accept either a 3-lead or 5-lead ECG cable.

ECG Modes

In auto mode, the QRS complexes are detected automatically. In manual mode, the QRS detection level appears on the screen as a horizontal line across the ECG wave. This enables the user to see exactly what is causing the heart rate counter to count.

In non-paced mode, no pace pulses are expected and no pace pulse rejection occurs. In paced mode, pace pulses are annotated with a small dash on the screen.

ST Segment Analysis

ST segment analysis is an optional feature. ST segment measurements can be recorded on up to three channels and three leads of a patient's ECG. The measurements are shown as numerics on the standard display, graphically in the ST analysis task window, and as part of patient vital signs and trend graphs. They can be recorded with reference beats at the bedside, or without beats at a central monitor or recorder.

Up to 242 sets of real-time algorithm outputs can be graphed, stored, and recalled, each with up to three channels of data. All stored waves are cleared after a discharge procedure when the monitor is turned off for more than three hours, or when monitoring mode is reset.

RESP Modes

In auto mode, the monitor measures respiration and adjusts the detection level automatically, depending on waveform height, presence of cardiac artifact, and absence of valid breaths. In manual mode, the user sets the detection level for measuring respiration.

Safety

To ensure the safety of the patient, the patient-applied parts are isolated from ground by optical isolators and a transformer. The module is also encapsulated in plastic.

ECG/RESP Module Exercises

1. The ECG generates numerics for which physiologic measurement?

   a. pulse
   b. pace pulses
   c. heart rate

2. Which module component prevents interference from the 50/60 Hz power line?

   a. Input protection network
   b. Right leg drive
   c. Highpass and lowpass filters

3. Which channels does the PPD check for pace pulses?

   a. Channels 1 and 2
   b. Channels 2 and 3
   c. Channels 1, 2, and 3

4. The RESP signal is detected by which component?

   a. Differential amplifier
   b. Impedance subtracter
   c. Measurement bridge
   d. Synchronous demodulator

5. The impedance subtracter subtracts which part of the RESP signal?

   a. heart rate
   b. respiratory rate
   c. cardiac impedance
   d. basic thoracic impedance

6. The number of ST segment measurements that can be stored and retrieved is ___.

7. Respiration is monitored from which two lead paths?

   a. LA and RA
   b. LA and RL
   c. LL and LA
   d. LL and RA

Answers
1. c
2. b
3. a
4. c
5. d
6. 242
7. d

Non-invasive Blood Pressure (NBP) Module Concepts

NBP Measurement

Description

Blood pressure is the pressure exerted by the blood against the walls of the blood vessels. Blood pressure measurement indicates the status of a patient's overall cardiac condition. Most frequently, blood pressure is measured in the arteries, as they are the vessels that carry blood from the heart to the body's major organs.

Non-invasive blood pressure measurements are taken by indirect methods of obtaining arterial blood pressure values, rather than by direct sampling of the blood stream. Various techniques can be used for measuring blood pressure non-invasively; all are based on compressing the artery by means of an occluding cuff, and measuring the effect of the compression on blood flow. The method used by Philips' patient monitoring systems is the oscillometric method. That is, the monitor measures the oscillation or changes in the volume of the arteries accompanying the heart beat.

Concepts

Blood pressure results from interactions between the heart's pumping force, the circulatory system's blood volume, and the body's vascular resistance to blood flow. Blood pressure measurements are related to cardiac output measurements in that both types are concerned with pumping force and vascular resistance. Cardiac output is a major determinent of blood pressure.

Concepts important to non-invasive blood pressure measurement are:

- **Systolic pressure -** The *highest* pressure of the blood against the arterial wall following ventricular contraction. It is a measure of how hard the heart is working and how much oxygen it requires.
- **Diastolic pressure** - The *lowest* pressure of the blood against the blood vessel wall following closure of the aortic valve, just before ventricular contraction. It is one measure of how much oxygen the heart is getting from the pulmonary capillaries. I
- **Pulse pressure** - The *difference* between the systolic and diastolic readings. This is the range of the pressure in the arteries.
- **Mean arterial pressure** - The average pressure used to push blood through the circulatory system. This measurement is an important index of blood flow and gas exchange in the capillaries.

Measurement Principle

In the oscillometric method, blood pressure is measured as oscillations superimposed on cuff pressure. The cuff, inflated around the patient's limb, senses arterial pulses as oscillations whose amplitude changes as the cuff is deflated. The initial oscillations are roughly equivalent to systolic pressure; the larger oscillations represent mean pressure; and the diastolic pressure is then derived from the mean pressure.

Measurement Acquisition

To take the measurement, the cuff is placed around the patient's limb and inflated until the artery is occluded, at a point just above systolic pressure. Blood movement ceases when cuff pressure is greater than arterial pressure. As cuff deflation commences, blood begins to flow through the artery at the systolic pressure, and the resulting pulsations are detected as oscillations. The cuff continues to deflate, and the amplitude of arterial oscillations increases until it reaches a maximum value, which represents mean arterial pressure. As cuff deflation continues, arterial pressure drops due to decreased resistance from the cuff pressure. Diastolic pressure is measured when the oscillations begin diminishing rapidly.

Output

Oscillometric blood pressure measurements are displayed as numerics.

Criteria for Proper Measurement

Factors affecting accurate measurement of non-invasive blood pressure are:

- Cuff size. A cuff that is too narrow may produce false BP readings that are too high. Conversely, a cuff that is too wide may produce false low readings.
- Cuff placement. The cuff should be placed on the arm at the level of the heart for a true zero reading. False high readings may be produced by cuffs that are applied too loosely.
- Artifacts, caused by shivering, bumping, or other rhythmic or external pressure.

Limitations

The oscillometric measurement has limitations in certain clinical situations. When a patient's condition makes regular arterial pressure pulses difficult to detect, the measurement is unreliable and takes longer to derive. The following conditions can interfere with the measurement:

- Patient Movement: If the patient is moving, shivering, or having convulsions, reliable measurement is difficult or impossible to obtain.
- Cardiac Arrhythmias: Irregular heart beats during arrhythmias make measurements unreliable or impossible.
- Pressure Changes: If the patient's blood pressure changes rapidly during the measurement period, measurements are unreliable.
- Severe Shock: Severe shock or hypothermia reduces blood flow to the peripheries and thus reduces arterial pulses, making pressure measurement unreliable.
- Obese Patients: A thick layer of fat surrounding the limb can muffle arterial pulses and prevent them from reaching the cuff, thus reducing the measurement's accuracy.
- Heart Rate Extremes: Measurements cannot be made if the heart rate is less than 15 bpm or greater than 300 bpm.
- Heart-lung Machine: Measurements are not possible if the patient is connected to a heart-lung machine.
- Movement of the tube

Plug-In Modules

Philips' M1008A and M1008B NBP Modules measure non-invasive blood pressure. The M1008B module replaced the M1008A.

NBP Measurements Exercises

1. The oscillometric method uses an occluding cuff to sense variations in which of the following:

   a. Cardiac output
   b. Ventricular contraction
   c. Arterial blood flow
   d. Capillary blood supply

2. What is the highest pressure of blood against the arterial wall called?

   a. Diastolic Pressure
   b. Systolic Pressure
   c. Mean Arterial Pressure
   d. Pulse Pressure

3. What is the lowest pressure of blood against the arterial wall called?

   a. Diastolic Pressure
   b. Systolic Pressure
   c. Mean Arterial Pressure
   d. Pulse Pressure

4. What is the term for the difference between the highest and lowest blood pressure measurement?

   a. Diastolic Pressure
   b. Systolic Pressure
   c. Mean Arterial Pressure
   d. Pulse Pressure

5. What does the highest amplitude oscillation on a non-invasive blood pressure waveform represent?

   a. Diastolic Pressure
   b. Systolic Pressure
   c. Mean Arterial Pressure
   d. Pulse Pressure

6. False blood pressure readings that are too high can be produced by which of the following circumstances?

   a. A cuff that is too narrow
   b. A cuff that is too wide
   c. A cuff applied too tightly

Answers
1. c
2. b
3. a
4. d
5. c
6. a

NBP Modules

Description

The M1008A and M1008B NBP Modules are non-invasive blood pressure measurement parameter units for Philips' patient monitoring devices. The M1008A Module is designed to be used with adult or pediatric patients, in both OR and ICU environments. The M1008B Module is designed to be used with adult, pediatric, or neonatal patients, in OR and ICU environments. The M1008A and M1008B Modules cannot be used simultaneously in a patient monitor.

Measurements

The modules produce numerics for the systolic, diastolic, and mean blood pressure values. No waveform is associated with these modules.

Three different methods can be used to obtain the measurements:

- **Manual:** For each request, one measurement of systolic, diastolic, and mean pressures is taken.
- **Auto:** Repeated measurements of the three values are taken at timed intervals specified by the user.
- **Stat:** Measurements of the three values are taken immediately and repeatedly over a period of five minutes. This method uses a faster measurement procedure but produces a less accurate reading.

Venous Puncture

This is not a measurement mode, rather the cuff is inflated to and held at a preset pressure to help you find a vein to puncture. The cuff deflates automatically after a fixed time, or you can deflate it manually.

Components

The following components carry out the major signal processing functions within the module.

Table 1-5 Major NBP Module Components

Component	Function
Pressure Pump	Inflates the cuff to preset limits, once or repeatedly, depending on the measurement method used.
Pressure Sensor	Measures cuff and arterial pressures using solid-state technology.
Overpressure Safety System	Triggers alarms at given pressures and time limits, and deflates the cuff.
Bandpass Filter	Extracts arterial pressure oscillations from the cuff pressure.
Deflation System	Automatically deflates the cuff at steps of a given magnitude.

Block Diagram

Figure 1-13 shows the NBP module's logical structure.

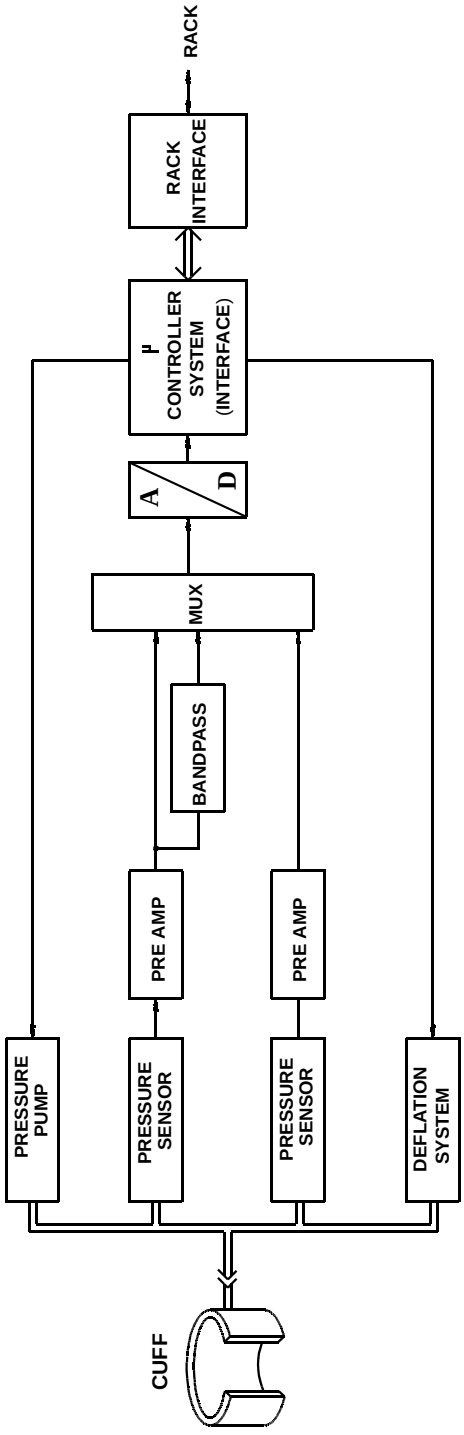


Figure 1-13 M1008A/B NBP Module Block Diagram

Theory of Operation

As NBP signals pass from the patient to the monitor, they progress through stages corresponding to logical sections of the module, as shown in the block diagram. Module-related faults can generally be isolated to one of the stages.

1 Signals from the patient are received by the pressure sensor through the cuff, which is connected to the module by a single tube. The cuff is inflated, deflated, and monitored by a pump, deflation system, and safety system controlled by a microprocessor.

Cuff inflation: During the initial cuff inflation, the cuff is inflated by the pressure pump to a set pressure which is determined by the mode. Thereafter the cuff is inflated by the pressure pump to a cuff pressure above the patient's systolic pressure. Depending on the measurement method used, inflation occurs once or repeatedly. When the cuff pressure is greater than the systolic pressure, the artery is occluded; the pressure sensor then detects only the cuff pressure.

Cuff Deflation: Cuff pressure is automatically released by the deflation system in steps of approximately 8 mmHg until the artery is only partially occluded. At that point, measurement and processing of arterial pressure oscillations begin and continue as the cuff pressure is progressively released.

2 **Detection:** As arterial pressure oscillations are detected, they are superimposed on the cuff pressure within the module's circuitry. After being extracted by the bandpass filter, they are passed to the microcontroller and measured.

3 **Measurement:** As the cuff is deflated, the magnitude of the oscillations as a function of cuff pressure increases until the mean arterial pressure is reached. When cuff pressure falls below the mean arterial pressure, oscillation magnitude begins to decrease.

The systolic and diastolic blood pressure values are deduced from the oscillometric signal by extrapolation, resulting in empirical values. Extrapolation uses the attenuation rate of the signal on both sides of the maximum readings. Invasive pressure measurement are also used as a reference to correlate non-invasive pressure.

NBP Module Features

Figure 1-14 shows the user controls and connector for the modules. The parts are described following the figure.

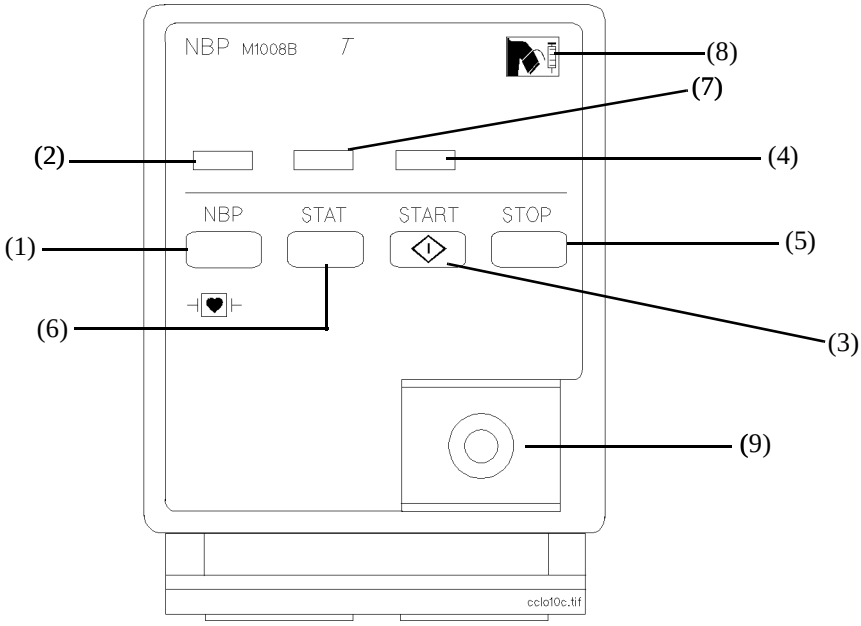


Figure 1-14 NBP Module Controls and Connectors

User Controls

1 **NBP Setup Key:** A single-press key used to enter the NBP setup screen.

2 **NBP Setup Indicator**: A green LED, lit when the NBP setup screen is activated.

3 **Start Key:** A single-press key, used to start the measurement cycle.

4 **Start Indicator:** a green LED, lit when the measurement cycle is entered.

5 **Stop Key:** a single-press key, used to stop the measurement cycle.

6 **Stat Key:** A single-press key, used to start a static measurement cycle.

7 **Stat Indicator:** A green LED, lit when the static measurement cycle is entered.

8 **Venous Puncture Symbol:** indicates that the module supports the Venous Puncture function.

Connectors

9 A standard NBP connector connects to the cuff.

NPB Modes

The M1008A Module offers adult and pediatric modes. The M1008B Module offers adult, pediatric, and neonatal modes.

Table 1-6 shows the cuff inflation limits for each mode.

Table 1-6 Cuff Inflation Limits, in mmHg

Mode	First Inflation	Subsequent Inflations, Above Systolic Pressure
Adult	165	25
Pediatric	125	20
Neonatal	100	15

Table 1-7 shows the measurement ranges for each mode.

Table 1-7 Measurement Ranges, in mmHg

Mode	Systolic	Diastolic	Mean
Adult	30 - 270	10 - 245	20 - 255
Pediatric	30 - 180	10 - 150	20 - 160
Neonatal	30 - 130	10 - 150	20 - 160

Safety

Table 1-8 gives the maximum limits that ensure patient safety.

Table 1-8 Maximum Safety Limits

Mode	Maximum Measurement Time	Maximum Time/Pressure	Over-pressure Maximum
Adult	100 seconds	120 seconds for pressure > 10 mmHg	330 mmHg for > 2 seconds
Pediatric	100 seconds	120 seconds for pressure > 10 mmHg	220 mmHg for > 2 seconds
Neonatal	60 seconds	60 seconds for pressure > 5 mmHg	165 mmHg for > 2 seconds

NBP Module Exercises

1. The NBP Modules provide numerics for which measurements:

   a. systolic, diastolic, and mean arterial pressures
   b. pulse rate
   c. heart and respiration rates
   d. a and b
   e. a, b, and c

2. The M1008B Module provides the same functions as the M1008A Module, with the addition of a mode for:

   a. Adults
   b. Pediatrics
   c. Neonates
   d. Pediatrics and Neonates

3. In which mode are measurements taken repeatedly over a period of five minutes?

   a. Manual mode
   b. Auto mode
   c. Stat mode

4. What is the function of the bandpass filter?

   a. It filters artifact from the mean arterial pressure.
   b. It extracts the arterial pressure oscillations from the cuff pressure.
   c. It protects the circuitry from high-frequency interference.

5. The systolic and diastolic blood pressure values are deduced from the oscillometric signal by _____,resulting in empirical values.

Answers
1. a
2. c
3. c
4. b
5. extrapolation

Cardiac Output (C.O.) Module Concepts

C.O. Measurement

Description

Cardiac output is an important measure of cardiac performance. It measures the volume of blood pumped into the circulatory system by the heart over a specified period of time. Cardiac output is closely related to blood pressure.

Several methods can be used for determining cardiac output. The method used by Philips' patient monitoring systems is the thermodilution method. With thermodilution, cardiac output is measured as the liters of blood pumped per minute into the pulmonary artery by the right ventricle of the heart.

Concepts

Cardiac output is determined by heart rate and stroke volume, as defined below.

- **Heart rate** - The number of times the heart beats in one minute.
- **Stroke volume** - The amount of blood pumped per beat.
- **Cardiac index** - A measure of an individual's cardiac output adequacy, calculated by dividing the cardiac output by the body surface area.

Measurement Principle

The thermodilution method is based on the principle that the flow rate of an unknown quantity of liquid can be determined by adding a known quantity of indicator and measuring its concentration downstream. Thermodilution involves injecting a cooled solution at a known temperature into the heart. The injectate solution mixes with and cools the warmer surrounding blood. When the blood leaves the heart, its temperature as a function of time indicates the rate of blood flow.

Measurement Acquisition

The measurement is taken with a pulmonary artery (PA) Swan Ganz catheter.

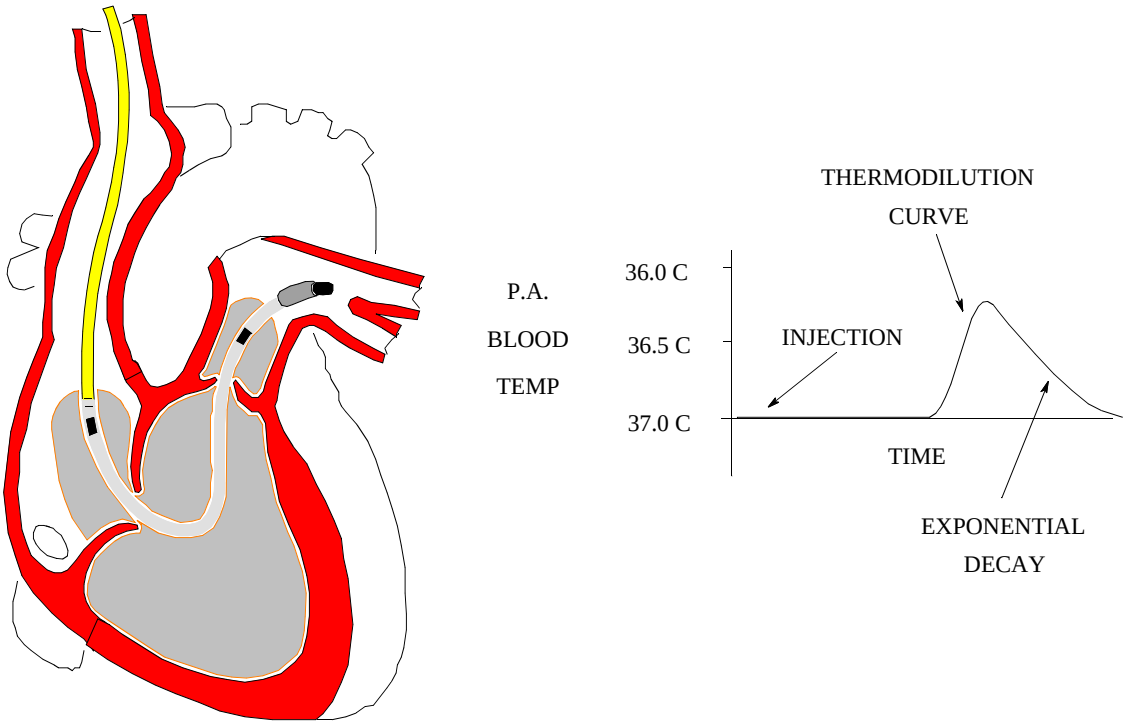
The catheter is inserted into the heart, with the proximal lumen opening positioned in the right atrium for introducing the injectate, and the thermistor, used for monitoring temperature, positioned in the pulmonary artery. Positioning of the catheter is gauged by using pressure measurements and X-rays of the catheter location. A small amount of thermal indicator is introduced into the right atrium. The indicator mixes with the blood in the right ventricle and approaches a temperature equilibrium. When the diluted blood reaches the pulmonary artery, the thermistor measures the decrease in blood temperature over time.

The temperature of the injectate solution can be measured either indirectly or directly. Indirectly, the temperature of the cooling bath is measured. Direct measurement uses a flow-through temperature probe to measure the injectate temperature as it is being

introduced into the catheter. The probe is positioned where the syringe injects the indicator into the proximal lumen port.

Output

The time/temperature curve resulting from the measurement resembles a bell-shaped curve, except that it has an exponential decay. The data are integrated to calculate the area beneath the curve. By convention, the y-axis of the graph shows decreasing temperature.



Criteria for Proper Measurement

Factors affecting accurate measurement of cardiac output include:

- Physiological conditions. Variations in cardiac rate and rhythm, cardiac abnormalities, or patient anxiety or movement can cause errors in measurement.
- Catheter conditions. A damaged or incorrectly positioned catheter, or a prematurely inflated balloon will cause measurement errors.
- Injectate factors. Inaccurate timing, volume, or temperature of injectate, as well as use of the wrong catheter port will result in errors.

Plug-In Modules

The M1012A C.O. Module provides the thermodilution cardiac output measurement.
References

Woods, Susan and Susan Osguthorpe. Cardiac Output Determination, in *AACN Clinical Issues in Critical Care Nursing.* [For bibliography: Susan Osguthorpe, ed. Philadelphia, JB Lippincott, 1993.]

C.O. Measurement Exercises

1. The time it takes for cooled blood to change temperature in the thermodilution method is used to derive which of the following measurements?

a. Mean arterial blood pressure
b. Core body temperature
c. Rate of blood flow
d. Blood gas exchange

2. Which term refers to the amount of blood pumped per heartbeat?

a. Cardiac index
b. Cardiac output
c. Heart rate
d. Stroke volume

3. Using thermodilution, at what location does the cold injectate solution leave the catheter and enter the heart?

a. Right atrium
b. Right ventricle
c. Pulmonary artery
d. Left atrium

4. The graph of the cardiac output measurement resembles:

a. A RESP waveform
b. A bell-shaped curve
c. Blood pressure oscillations
d. An inverted QRS wave

Answers
1. c
2. d
3. a
4. b

C.O. Module

Description

The M1012 C.O. Module is a cardiac output measurement parameter unit. It is designed to be used with adult patients in an ICU or OR environment. It uses the thermodilution method to generate the measurement.

Measurements

The C.O. Module produces a thermodilution curve, together with numerics for the cardiac output, cardiac index, blood temperature, and injectate temperature values.

Components

The following components carry out the major signal processing functions within the module.

Table 1-9 Major C.O. Module Components

Component	Function
Reference Switching Matrix	Calibrates the measurement using reference resistors.
Differential Amplifier	Amplifies the signals from the reference switching matrix.
Dual-Slope, Analog-to-Digital Converter	Digitizes the analog signals from both the blood and injectate channels.

Block Diagram

Figure 1-15 shows the block diagram of the C.O. Module M1012A.

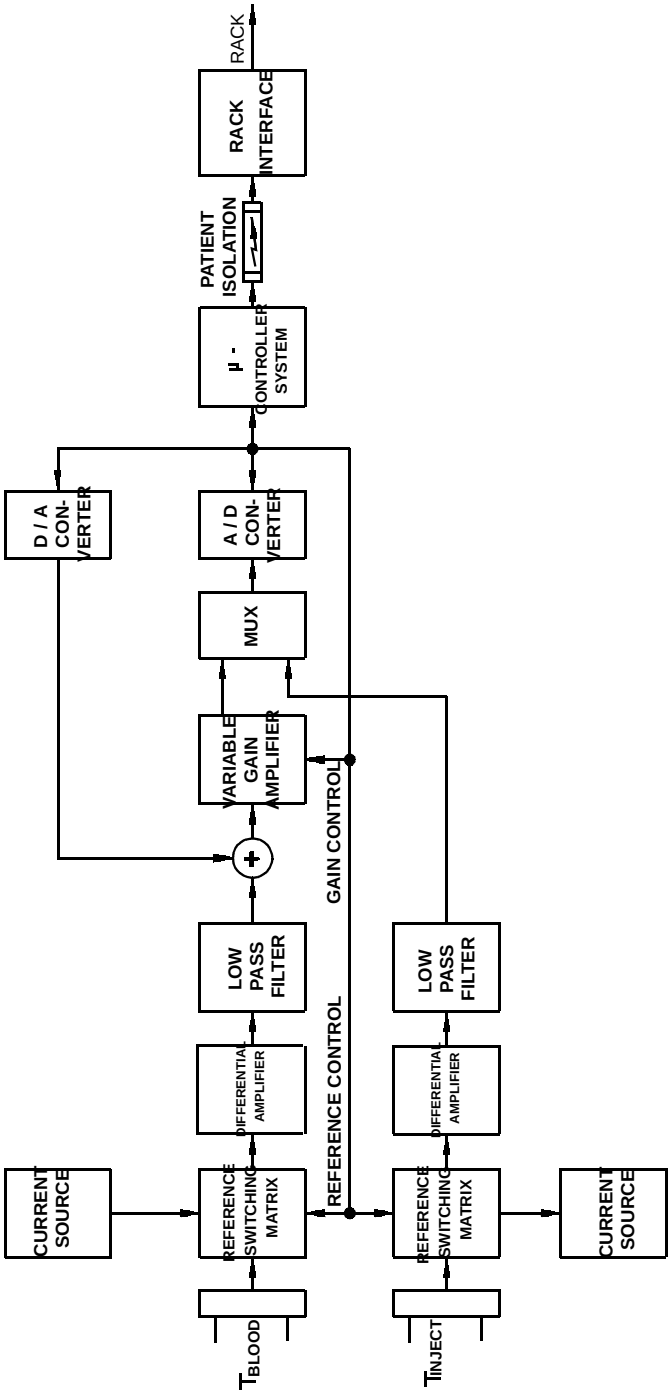

RACK
RACK INTERFACE
PATIENT ISOLATION
µ - CONTROLLER SYSTEM
D / A CON-VERTER
A / D CON-VERTER
MUX
VARIABLE GAIN AMPLIFIER
GAIN CONTROL
LOW PASS FILTER
LOW PASS FILTER
DIFFERENTIAL AMPLIFIER
DIFFERENTIAL AMPLIFIER
REFERENCE CONTROL
CURRENT SOURCE
REFERENCE SWITCHING MATRIX
REFERENCE SWITCHING MATRIX
CURRENT SOURCE
TBLOOD
TINJECT

Figure 1-15 M1012A C.O. Module Block Diagram

Theory of Operation

The module has two separate circuits for measuring blood and injectate temperatures. The signals progress through the module as follows:

1 **Blood Channel:** The temperature sensor distal, T_{blood}, in the catheter is connected to a reference switching matrix that continuously compares the input to reference resistors for continuous calibration of the measurement. The sequentially produced voltages across the reference and sensor resistors are amplified before being input to a low-pass filter. The filtered signals are then passed through the multiplexer to the analog-to-digital converter.

2 **Injectate Channel**: The temperature sensor, $T_{injectate}$, which is either a flow-through or bath probe, is connected to a separate reference-switching matrix on its own circuit. The matrix compares the signals to the same reference resistors used for the blood circuit. The output is amplified, filtered, and then multiplexed with the blood temperature signal before the signals are digitized for the microcontroller.

3 The cardiac output measurement is obtained by first compensating for the blood temperature by the digital-to-analog converter. The difference signal is then amplified by a variable amplifier with a high gain, which increases the sensitivity for measuring the thermodilution curve.

The continuous calibration, linearization, control, and conversion to degrees C is performed by the software.

C.O. Module Features

Figure 1-16 shows the user controls and connector for the C.O. Module. The parts are described following the figure.

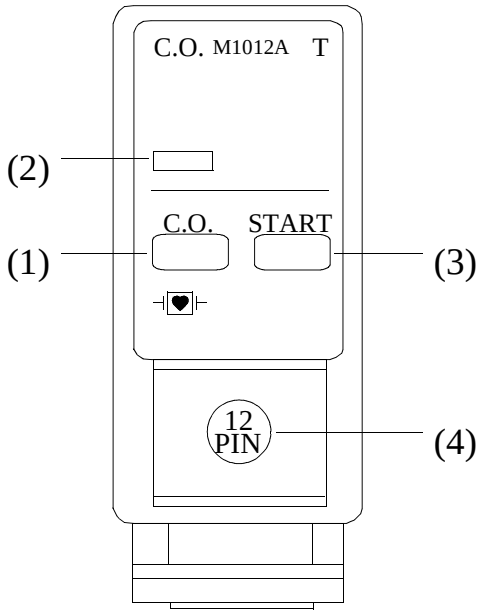


Figure 1-16 Cardiac Output Module Controls and Connectors

User Controls

1 **C.O. Setup Key --** A single-press key used to enter the cardiac output setup screen.

2 **C.O. Setup Indicator --** A green LED, lit when the cardiac output setup screen is activated.

3 **Start Key --** A single-press key, used to enter the measurement cycle.

Connectors

4 This is a standard 12-pin connector for use with a catheter, thermistor, and start/stop switch.

Safety

To ensure the safety of the patient, the patient-applied part is isolated from ground by opto-couplers and a transformer. The module is also encapsulated in plastic.

C.O. Module Exercises

1. The M1012A C.O. Module can be used with which patients?

   a. adults
   b. adults and pediatrics
   c. adults, pediatrics, and neonates

2. Which component of the C.O. Module calibrates the measurement using reference resistors?

   a. Differential amplifier
   b. Reference switching matrix
   c. Dual-slope analog-to-digital converter
   d. Digital-to-analog converter

3. Which component converts the measurement to degrees C?

   a. Reference Switching Matrix
   b. Dual-Slope Analog-to-Digital Converter
   c. Digital-to-analog converter
   d. Application software

Answers
1. a
2. b
3. d

Cardiac Output #C10 (CCO) Module Concepts (CMS only)

This chapter describes the **Transpulmonary Thermodilution method** of measuring the Cardiac Output.
For information regarding the Right Heart method, please refer to chapter “Cardiac Output (C.O.) Module Concepts” on page 1-40.

C.O. #C10 (CCO) Measurement (CMS only)

Description

The transpulmonary thermodilution method requires the M1012A #C10 Cardiac Output Module. Option C10 is Philips’ implementation of Pulsion Medical Systems PiCCO™ method, which offers the following features:

- Measurement of Cardiac Output (C.O.), Intrathoracic Blood Volume (ITBV) and Extravascular Lung Water (EVLW)[1] using transpulmonary thermodilution.
- Measurement of Continuous Cardiac Output (CCO), Stroke Volume (SV), Systemic Vascular Resistance (SVR) and Stroke Volume Variation (SVV) by means of Pulse Contour analysis of the arterial blood pressure waveform.

Concepts

The PiCCO™ method is a combination of the transpulmonary thermodilution technique and blood pressure waveform analysis to measure Cardiac Output (C.O.), Intrathoracic Blood Volume (ITBV) and Extravascular Lung Water (EVLW)[1].

Measurement Principle

The thermodilution method is based on the principle that the flow rate of an unknown quantity of liquid can be determined by adding a known quantity of indicator and measuring its concentration downstream. Thermodilution involves injecting a cooled solution at a known temperature into the heart. The injectate solution mixes with and cools the warmer surrounding blood. When the blood leaves the heart, its temperature as a function of time indicates the rate of blood flow.
The thermodilution measurement is also used for the calibration of the Continuous Cardiac Output (CCO), derived by pulse contour analysis from the arterial blood pressure wave.

Measurement Acquisition

The measurement of transpulmonary thermodilution cardiac output and blood pressure requires a central venous line and an arterial thermal dilution catheter placed downstream from the heart, in or near the aorta, e.g. the femoral or the axillary artery. The injectate is injected through the central venous line. The temperature of the injectate solution is measured by a flow-through temperature probe as it is being introduced into the central venous line. The injectate mixes with the blood in the right ventricle and approaches a temperature equilibrium. When the diluted blood reaches

1. EVLW is not available in U.S.A.

the artery with the arterial catheter, the thermistor measures the decrease in blood temperature over time.
The blood pressure wave acquisition is achieved with the M1006A/B Invasive Pressure module. For details regarding this module please refer to “Invasive Blood Pressure Module Concepts” on page 2-3.

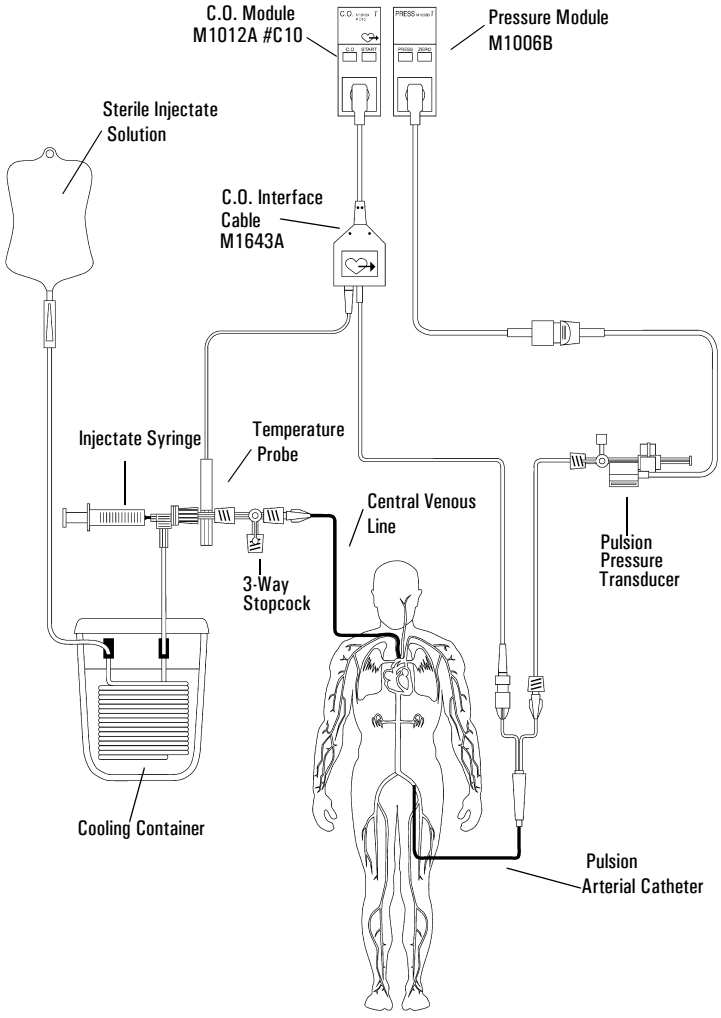
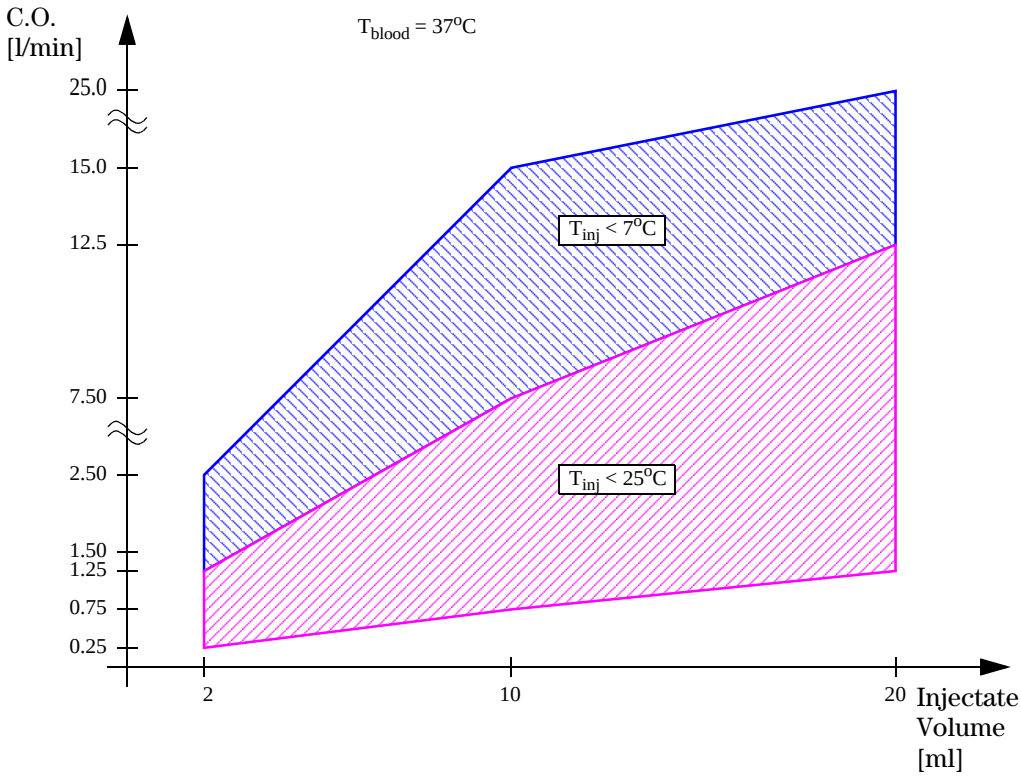


Figure 1-17 Setup for Transpulmonary Thermodilution and Continuous Cardiac Output

Injectate Temperature and Volume

Based on the injectate temperature and the patient's cardiac output the necessary injectate volume differs.The following graphic is a guideline on which injectate volume should be used.



The dilution of injectate is also influenced by the extravascular tissue. The Extravascular Thermovolume Index (ETVI) is a quality indicator which quantifies this influence. ETVI is calculated based on the patient's body weight and only applies to the current single transpulmonary thermodilution measurement. For patients with high ETVI values, the accuracy of the transpulmonary thermodilution measurement may be reduced. It is recommended to use a higher injectate volume and/or colder injectate in these patients based on the following table.

Patient Weight	Cold Injectate		Room Temp. Injectate	
	ETVI < 10	ETVI ≥ 10	ETVI < 10	ETVI ≥ 10
< 3 kg	2 ml	2 ml	3 ml	Use cold injectate
< 10 kg	2 ml	3 ml	3 ml	
< 25 kg	3 ml	5 ml	5 ml	
< 50 kg	5 ml	10 ml	10 ml	
< 100 kg	10 ml	15 ml	15 ml	
≥ 100 kg	15 ml	20 ml	20 ml	

C.O. #C10 (CCO) Module (CMS only)

This section describes the **Transpulmonary Thermodilution method** of measuring the Cardiac Output.
For information regarding the Right Heart method, please refer to chapter “Cardiac Output (C.O.) Module Concepts” on page 1-40.

Description

The M1012 #C10 C.O. Module is a cardiac output measurement parameter unit. It is designed to be used with adult, pediatric or neonatal patients down to 2kg of weight in the range of hospital environments. It uses the transpulmonary thermodilution method and the pulse contour analysis to generate the measurement.

Measurements

The C.O. #C10 Module produces a thermodilution curve, together with numerical values for the transpulmonary thermodilution Cardiac Output **(C.O.)**, IntraThoracic Blood Volume **(ITBV)** and ExtraVascular Lung Water **(EVLW)**[1]. The thermodilution measurement is also used for the calibration of the Continuous Cardiac Output **(CCO)**, derived by pulse contour analysis from the arterial blood pressure wave.

Components

The following components carry out the major signal processing functions within the module.

Table 1-10 Major C.O. #C10 Module Components

Component	Function
Reference Switching Matrix	Calibrates the measurement using reference resistors.
Differential Amplifier	Amplifies the signals from the reference switching matrix.
Dual-Slope, Analog-to-Digital Converter	Digitizes the analog signals from both the blood and injectate channels.

Block Diagram

Figure 1-18 shows the block diagram of the C.O. Module M1012A #C10.

1. EVLW is not available in U.S.A.

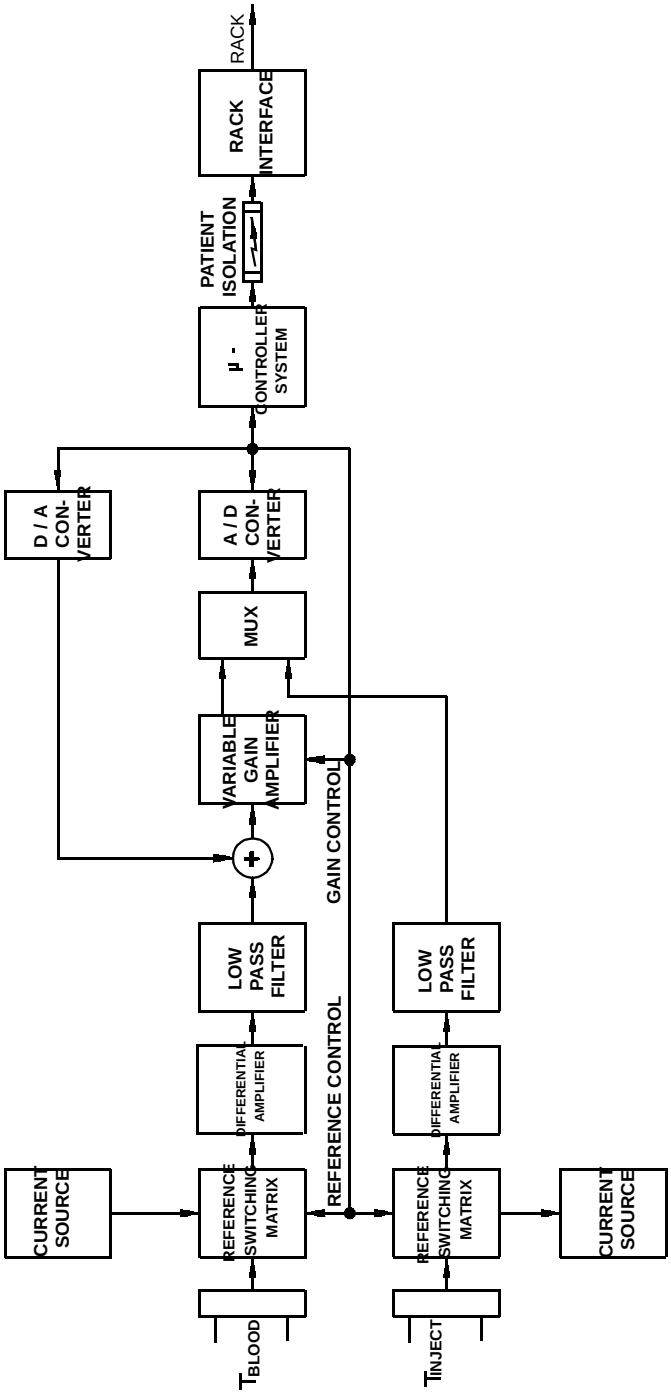


Figure 1-18 M1012A C.O. #C10 Module Block Diagram

Theory of Operation

The module has two separate circuits for measuring blood and injectate temperatures. The signals progress through the module as follows:

1 **Blood Channel:** The temperature sensor distal, T_{blood}, in the catheter is connected to a reference switching matrix that continuously compares the input to reference resistors for continuous calibration of the measurement. The sequentially produced voltages across the reference and sensor resistors are amplified before being input to a low-pass filter. The filtered signals are then passed through the multiplexer to the analog-to-digital converter.

2 **Injectate Channel**: The temperature sensor, $T_{injectate}$, which is a flow-through probe, is connected to a separate reference-switching matrix on its own circuit. The matrix compares the signals to the same reference resistors used for the blood circuit. The output is amplified, filtered, and then multiplexed with the blood temperature signal before the signals are digitized for the microcontroller.

3 The cardiac output measurement is obtained by first compensating for the blood temperature by the digital-to-analog converter. The difference signal is then amplified by a variable amplifier with a high gain, which increases the sensitivity for measuring the thermodilution curve.

The continuous calibration, linearization, control, and conversion to degrees C is performed by the software.

C.O. #C10 (CCO) Module Features

Figure 1-19 shows the user controls and connector for the C.O. #C10 Module. The parts are described following the figure.

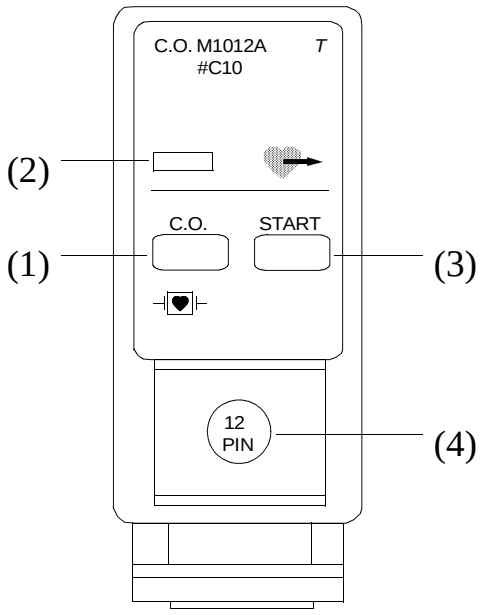


Figure 1-19 C.O. #C10 Module Controls and Connectors

User Controls

1 **C.O. Setup Key --** A single-press key used to enter the cardiac output setup screen.

2 **C.O. Setup Indicator --** A green LED, lit when the cardiac output setup screen is activated.

3 **Start Key --** A single-press key, used to enter the measurement cycle.

Connectors

4 This is a standard 12-pin connector for use with a catheter, thermistor, and start/stop switch.

Safety

To ensure the safety of the patient, the patient-applied part is isolated from ground by opto-couplers and a transformer. The module is also encapsulated in plastic.

Arterial Oxygen Saturation/Plethysmography (SpO_2/Pleth) Module Concepts

SpO_2 Measurement

Description

SpO_2 is a measure of arterial oxygen saturation obtained using the pulse oximetry method. Pulse oximetry is a continuous, non-invasive method of measuring the oxygen content of the arterial hemoglobin. It measures the amount of light transmitted from a light source through a patient's tissue to the receiving sensor.

Concepts

The following concepts are important to the measurement of arterial oxygen saturation:

SaO_2 - Arterial oxygen saturation, or the percentage of oxygen carried by the red blood cells within the arteries. Approximately 97 per cent of the oxygen is normally carried on the red blood cells; the rest is dissolved in the plasma. A decrease in hemoglobin will decrease the amount of oxygen available to the tissues.

SpO_2 - The arterial oxygen saturation measurement obtained from pulsations in the arterioles using pulse oximetry.

Hemoglobin - The protein in red blood cells that transports oxygen (O_2) and carbon dioxide (CO_2) molecules to and from the body's tissues. A hemoglobin molecule (Hb) attaches to oxygen molecules in the pulmonary alveoli and releases them to other systemic tissue cells. When carrying oxygen, it forms oxyhemoglobin (HbO_2). Oxygen saturation can be measured by calculating the percentage of HbO_2 to Hb.

Ventilation - The volume of air that reaches the pulmonary alveoli through breathing. Ventilation refers to the process in which air enters the alveoli, enabling the capillaries to receive oxygen and release carbon dioxide.

Perfusion - Passage of blood through a vascular bed. Perfusion facilitates gas exchange in the capillary beds of the lung and the tissue. In well perfused organs, blood flows evenly through the capillaries, ensuring a steady supply of available oxygen. Perfusion also enables the body to release carbon dioxide.

Photo plethysmography - A method of measuring oxygen saturation in relation to blood volume using the principle of light absorption. Also called absorption plethysmography.

Pulse oximetry - A method of measuring arterial oxygen saturation using two wavelengths of light and the pulsatile activity of the blood.

Measurement Principle

Pulse oximetry is based on the principle that red blood cells absorb different amounts of light depending on the amount of oxygen they contain. When light is transmitted through body tissue such as a finger, it is absorbed differently by skin pigments, tissue, cartilage, bone, arterial blood, and venous blood. Most of these substances absorb light at a constant rate. The blood in the arteries and arterioles, however, is pulsatile. As the blood vessels expand and contract, the length of the light path is altered, affecting its absorption. Because the only significant variable is due to pulsing blood, the ratio of HbO_2 to Hb can be measured in the pulsatile part of the signal to reveal the oxygen saturation of the arterial flow. The measurement is derived using two wavelengths of light -- one in the red region and one in the infrared -- to measure maximum and minimum absorption differences between the two molecules.

Measurement Acquisition

The SpO_2 measurement is taken by means of an optical cuff that is placed on the patient's fingertip. From the transmitting side of the transducer, red and infrared light is scattered through the capillary bed and detected by a photo-diode on the receiving side. The measurement is independent of skin permantation, tissue absorbtion, and other constants.

Output

The resulting measurement is plotted as a plethysmogram. The waveform is proportional to the blood volume changes, the pulse rate, and the relative perfusion of the skin and transducer.

Criteria for Proper Measurement

A number of factors can affect the accuracy of the measurement or the ability to obtain it.

- Incorrect positioning may cause incorrect measurement. The light emitter and the photodetector are directly opposite each other and all the light from the emitter passes through the patient's tissues when it is positioned correctly. Pushing the transducer on too far or not far enough, may result in inaccurately low or high SpO_2 readings, respectively.
- The measurement requires pulsatile activity. When pulses drop below a certain threshold, no measurement can be taken. This situation might arise from conditions such as shock, hypothermia, vasoactive drugs, inflated blood pressure cuffs, or any condition in which tissue perfusion is impaired.

  Conversely, situations may exist in which venous blood is pulsatile, such as from venous obstructions or certain cardiac conditions. In such cases, the measurement will be erroneously low due to the inclusion of the venous blood in the pulsatile signal.
- Optical interference can cause inaccurate measurements. Pulse oximetry assumes that only two light absorbers will be measured: HbO_2 and Hb. However, other elements may be present in the blood with similar absorption properties, thus causing falsely low readings. Examples of these are carboxyhemoglobin (HbCO), methemoglobin (MetHb), and several dyes used in clinical tests.

  Interference from ambient lights can be prevented by covering the finger cuff with an opaque material.

- Any factor that affects the transmission of light through the tissue, such as nail polish, can affect the measurement.

- Motion artifact may interfere with the accuracy of the measurement, as it has the same frequency range as pulse activity.

Plug-In Modules

The M1020A SpO_2/PLETH Module provides the arterial oxygen saturation measurement. References

Ahrens, Tom. Respiratory Monitoring in Critical Care, in *AACN Clinical Issues in Critical Care Nursing.* [For bibliography: Susan Osguthorpe, ed. Philadelphia, JB Lippincott, 1993.]

SpO_2 Measurement Exercises

1. Which measurement method is based on principles of light-absorbing properties of blood?

   a. Plethysmography
   b. Pulse Oximetry
   c. Thermodilution

2. What factor determines the difference in definition between SaO_2 and SpO_2?

   a. The site where the measurement is taken.
   b. The method used to take the measurement.
   c. The clinical application for which the measurement is needed.

3. The molecule in the blood that transports oxygen to the cells of the body is:

   a. Hb
   b. HbCO
   c. HbO_2
   d. MetHb

4. Which term refers to the process of gas exchange in the cells by means of capillary blood flow?

   a. Perfusion
   b. Transmutation
   c. Ventilation

5. Which condition does pulse oximetry require in order to measure SpO_2?

   a. Adequate ambient light
   b. The absence of CO_2 in the blood
   c. Pulsatile blood activity
   d. An unconscious patient

Answers
1. b
2. b
3. c
4. a
5. c

SpO_2/PLETH Module

Description

The M1020A SpO_2/PLETH Module is a pulse, arterial oxygen saturation, and plethysmogram measurement parameter unit.

Measurements

The module produces numerics for the arterial oxygen saturation value and the pulse rate, along with a real-time waveform for the plethysmogram. The module also provides a perfusion indicator value for the pulsatile arterial blood flow.

Components

The following components carry out the major signal processing functions within the module.

Table 1-11 Major SpO_2/PLETH Module Components

Component	Function
Input Protection Network	Protects the module against defibrillator spikes.
Current-to-Voltage Converter	Converts the current from the photodiode, and removes ESU interference.
Ambient Light Rejection Circuitry	Subtracts ambient light from the signal
Over-range Detector	Detects overload voltages caused by strong ambient light and high LED currents.
Dark Light Subtracter	Subtracts the dark voltage from the red and infrared voltage.
Analog-to-Digital Converter	Converts the signal for processing;

Block Diagram

Figure 1-20 shows the block diagram of the SpO_2/PLETH Module M1020A.

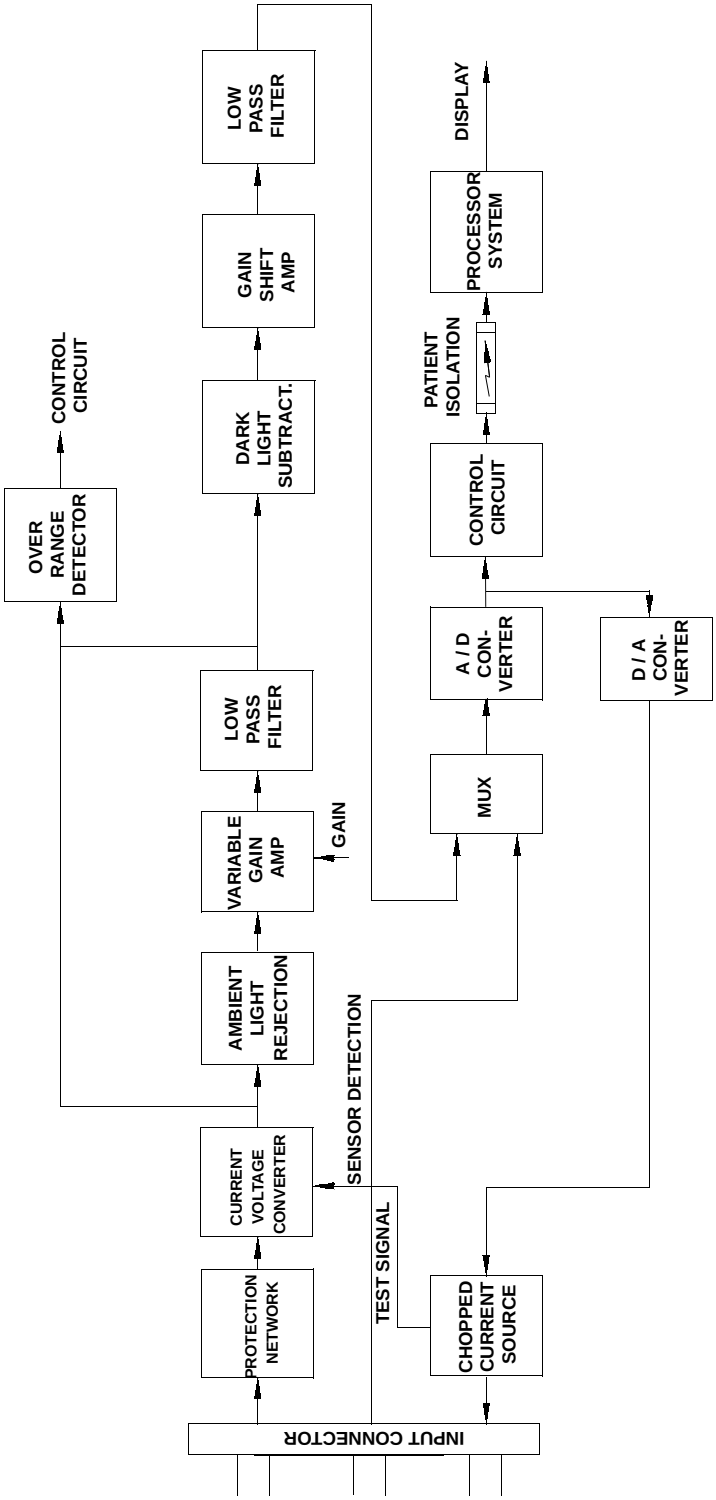

INPUT CONNECTOR
PROTECTION NETWORK
CURRENT VOLTAGE CONVERTER
AMBIENT LIGHT REJECTION
VARIABLE GAIN AMP
GAIN
LOW PASS FILTER
DARK LIGHT SUBTRACT.
GAIN SHIFT AMP
LOW PASS FILTER
OVER RANGE DETECTOR
CONTROL CIRCUIT
SENSOR DETECTION
TEST SIGNAL
CHOPPED CURRENT SOURCE
MUX
A / D CON-VERTER
CONTROL CIRCUIT
PATIENT ISOLATION
PROCESSOR SYSTEM
DISPLAY
D / A CON-VERTER

Figure 1-20 M1020A SpO_2/PLETH Module Block Diagram

Theory of Operation

The signals progress through the module as follows:

Light Transmission: Two LEDs in the transducer generate red and infrared light that is transmitted through a well-perfused capillary bed in the patient's finger or toe.

The LEDs are controlled by the software and are supplied with a chopped current of 375 Hz. Sensor-detection circuitry detects both the presence and type of transducer connected. To optimize the amplitude in the pulse sequence, the chopped current source is independently controlled by the digital-to-analog converter. A test signal can be generated in the input stage by switching the sensor signals off.

A photodiode directly opposite the LEDs detects the amount of light passing through the tissue, and generates a current that represents the intensity of the light detected for each wavelength. The current consists of a DC part, representing ambient light, modulated with a small AC signal from the pulsatile blood flow. The current passes through the input protection network and is converted to voltage.

Over-range Detection: The over-range detector checks the input voltage for overload due to an excessively high current from ambient light. It also checks the pulsatile signal for overload from the transducer light source.

Ambient Light Rejection: The ambient light is then subtracted by the high pass filter. The signal amplitude is optimized in the variable amplifier and passed to a low pass filter, where the dark signal, representing the ambient light current, is subtracted from the red signal. The high pass and low pass filters act as a demodulator. The pulse sequence representing red, infrared, and plethysmogram voltages is then amplified, multiplexed, and digitized.

Signal Processing: From the digitized signal, the microprocessor derives the oxygen saturation value and the plethysmogram waveform for display. It can also derive a pulse value from the PLETH signal, if configured to do so.

SpO_2/PLETH Module Features

Figure 1-21 shows the user controls and connector for the module. The parts are described following the figure.

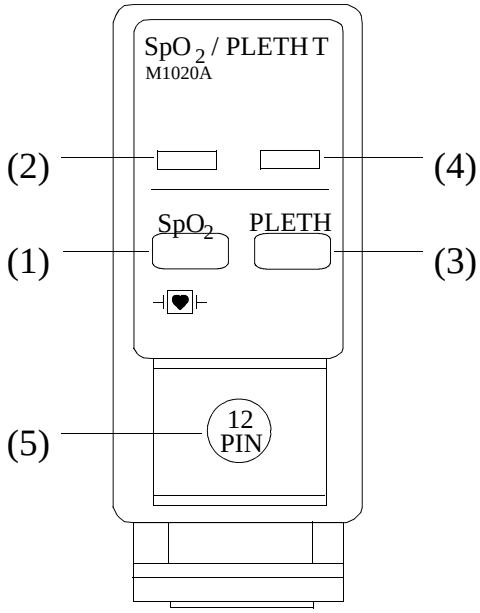


Figure 1-21 SpO_2/PLETH Module Controls and Connectors

User Controls

1 **SpO_2 Setup Key** -- A single-press key used to enter the SpO_2 setup screen.

2 **SpO_2 Setup Indicator** -- A green LED, lit when the SpO_2 setup screen is activated.

3 **PLETH Setup Key** -- A single-press key used to enter the PLETH setup screen.

4 **PLETH Setup Indicator** -- A green LED, lit when the PLETH setup screen is activated.

Connectors This is a standard 12-pin connector for use with an SpO_2/PLETH transducer.

Safety To ensure the safety of the patient, the patient-applied part is isolated from ground by opto-couplers and a transformer. The module is also encapsulated in plastic.

PLETH Waveform

The waveform can be configured for either of two settings: Perfusion or SpO_2 SQI Mode. These settings control the way the PLETH wave is adjusted for display on the screen.

The Perfusion Indicator, if configured, functions independently from the selected wave presentation and gives additional information about arterial blood perfusion. It is a scaled ratio between two different light-absorbing volumes: one that varies with time and one that is constant. The perfusion indicator is directly related to the amount of blood perfusion at the transducer site.

SpO_2 SQI Mode is the factory default. It automatically and continuously adjusts the size of the wave, which represents the quality of the SpO_2 measurement signals. Manual wave adjustments in this mode are not possible. If the signal quality becomes weak, the waveform becomes progressively smaller, and the perfusion indicator reading typically falls below 1. If the signal degrades below an acceptable level, the wave becomes flat and an INOP alarm results. A poor signal may be caused by poor perfusion at the transducer site, or by the transducer; it is *not* related to low oxygen saturation.

Figure 1-22 contains an example of a typical waveform in SpO_2 SQI Mode.

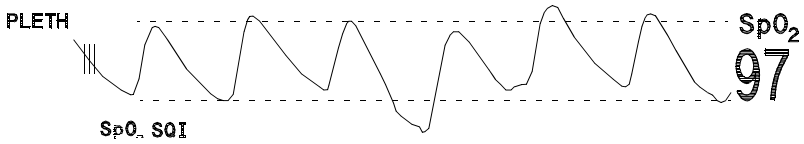


Figure 1-22 Waveform in SpO_2 SQI Mode

Perfusion Mode automatically adjusts the waveform but also allows manual adjustment by the user. In this mode, the size of the waveform is *not* related to the quality of the SpO_2 signal.

SpO_2/PLETH Module Exercises

1. Which component controls the current to the chopped current source?

   a. Current-to-voltage converter
   b. Digital-to-analog converter
   c. Input protection network
   d. Over-range detector

2. Which component removes ESU interference?

   a. Current-to-voltage converter
   b. Digital-to-analog converter
   c. Input protection network
   d. Low-pass filter

3. Which setting produces a waveform that indicates the quality of the SpO_2 measurement signal?

   a. Perfusion mode
   b. Pulse mode
   c. SpO_2 SQI mode

Answers
1. b
2. a
3. c

Temperature (TEMP) Module Concepts

TEMP Measurement

Description

Temperature is the measurement of the amount of heat present in a region of the body. Various regions and tissues within the body have widely divergent temperatures, and many factors can influence temperature change. Body temperature can indicate conditions such as infection, inflammation, and antigenic responses, as well as effectiveness of treatment. Careful monitoring of body temperature is vital for critically ill patients.

Concepts

Thermometry can include a broad range of temperature-sensing devices, such as mercury thermometers, thermistors, thermocouples, and units that reflect infrared light. Because heat increases the movement of molecules, thermometry uses scales based on the thermodynamic properties of given substances.

Measurement Principle

The temperature measurement used by Philips' patient monitoring systems is based on a thermistor whose resistance is inversely proportional to its temperature. By measuring the thermistor's resistance, its temperature can be calculated. The resistance of the thermistor is measured by passing a current through it and measuring the voltage developed across it.

The delta temperature measurement reflects two different temperature probe values and calculates the difference in temperature between the two measurements. A temperature delta from different sites can be diagnostic of an altered physiologic state.

Measurement Acquisition

Temperature can be measured by a variety of temperature probes designed for use with different anatomic sites. The choice of site is determined by the type of information needed by the clinician.

Output

Temperature measurements can be graphed over time or represented as numerics, depending on the application.

Criteria for Proper Measurement

A thermometer should provide a quick, accurate, and reliable measurement of temperature. Factors affecting accurate measurement of temperature include:

- Frequency and accuracy of calibration.
- Appropriateness of the reference standard against which the thermometer is calibrated.
- Choice of anatomic site for taking the measurement.

- Environmental conditions.
- Activity and movement of the patient.

Plug-In Modules

The M1029A TEMP Module provides the temperature measurement. I

References

Holtzclaw, Barbara, Monitoring Body Temperature, in *AACN Clinical Issues in Critical Care Nursing.* [For bibliography: Susan Osguthorpe, ed. Philadelphia, JB Lippincott, 1993.]

TEMP Measurement Exercises

1. Thermistors, thermocouplers, and infrared reflectors are an integral part of which measurement technique?

a. Thermodilution
b. Thermometry
c. Pulse Oximetry

2. The resistance of the temperature thermistor is _____ proportional to its temperature.

3. How many temperature measurements are taken to calculate an individual's temperature difference?

a. one
b. two
c. three

4. Factors affecting accurate measurement of temperature include _____ and _____.

Answers
1. b
2. inversely
3. b
4. Any of the following:
Calibration
Reference standard
Anatomic site
Environmental conditions.
Patient's Activity

TEMP Module

Description

The M1029A TEMP Module is a temperature measurement parameter unit. It is designed to be used with adult, pediatric, or neonatal patients in an ICU or OR environment.

Measurements

The TEMP Module produces numerics in degrees Celsius for the temperature. Different labels can be selected for temperature readings from different measurement sites.

Components

The following components carry out the major signal processing functions within the module.

Table 1-12 Major TEMP Module Components

Component	Function
Reference Switching Matrix	Calibrates the measurement using reference resistors.
Differential Amplifier	Amplifies the signals from the reference switching matrix.
Dual-Slope, Analog-to-Digital Converter	Digitizes the analog signals from the temperature and thermistor calibration.

Block Diagram

Figure 1-23 shows the block diagram of the TEMP Module M1029A.

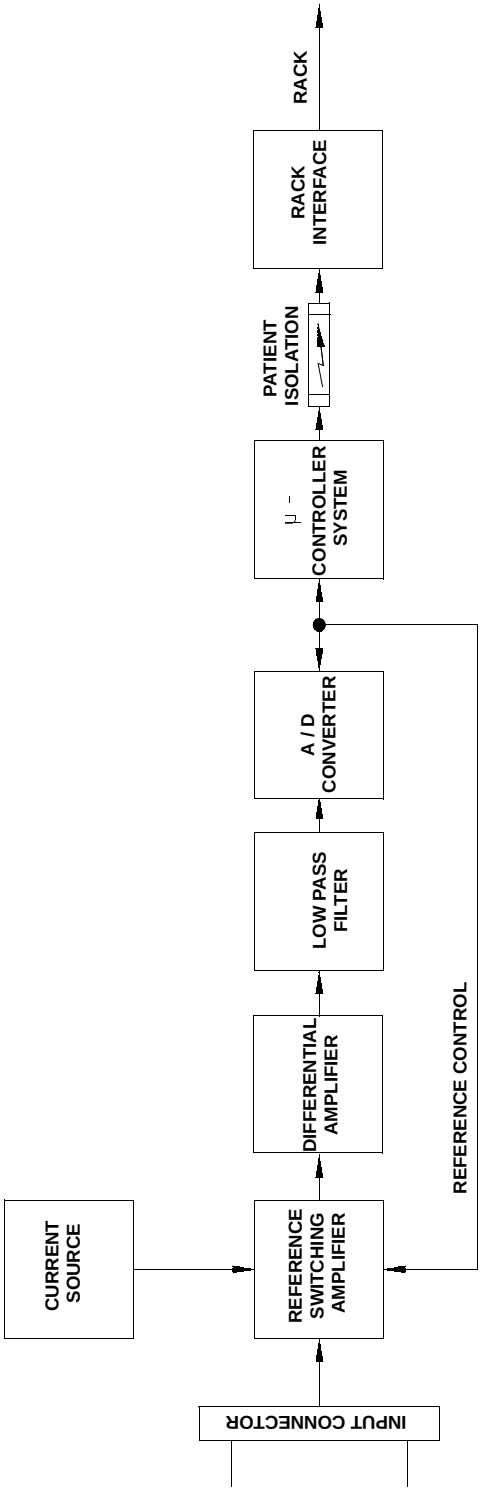


Figure 1-23 TEMP Module Block Diagram

Theory of Operation

The signals progress through the module as follows:

The thermistor in the temperature probe is connected to a reference switching matrix that continuously compares the input to reference resistors for continuous calibration of the measurement. The sequentially produced voltages across the reference and probe resistors are amplified, filtered, and digitized. The continuous calibration, linearization, control, and conversion to degrees C is performed by the software.

TEMP Module Features

Figure 1-24 shows the user controls and connector for the TEMP Module. The parts are described following the figure.

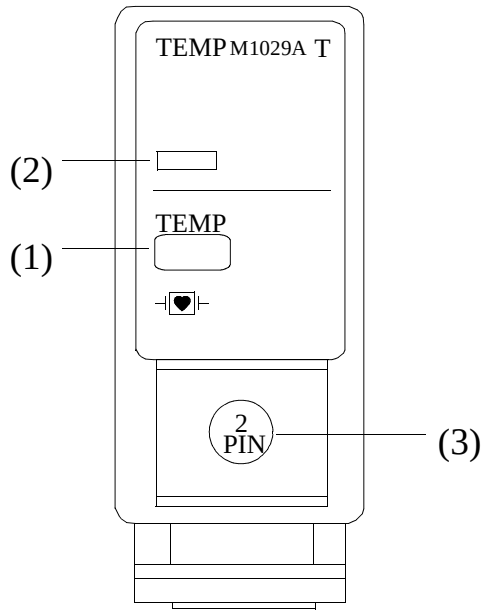


Figure 1-24 TEMP Module Controls and Connectors

User Controls

1 **TEMP Setup Key --** A single-press key used to enter the temperature output setup screen.

2 **TEMP Setup Indicator --** A green LED, lit when the temperature setup screen is activated.

Connectors

3 This is a 2-pin connector for use with standard 217xx series temperature probes (yellow spring series 400 characteristics) and 218xx series disposable temperature probes (the 218xx series probes are not sold in Germany.)

Safety

To ensure the safety of the patient, the patient-applied part is isolated from ground by opto-couplers and a transformer. The module is also encapsulated in plastic.

TEMP Module Exercises

1. The M1029 TEMP Module can be used with which patients?

   a. adults
   b. adults and pediatrics
   c. adults, pediatrics, and neonates

2. To which component is the temperature probe connected?

   a. Current source
   b. Reference switching matrix

3. The module can be used with YSI Series _____ temperature probes.

   a. 100
   b. 200
   c. 400

4. What isolates the patient from the module's current?

   a. Opto-couplers
   b. Input Connector
   c. Input Protection Network

Answers
1. c
2. b
3. c
4. a

Recorder Module Concepts

Recorder Module (M1116A)

Description

The M1116A Recorder Module provides thermal array recording capability for the Philips patient monitoring family, including the V24/V26. Like the M1116B Recorder Module, it can write up to three overlapped waveforms and three lines of annotation. The M1116A offers eight recording speeds; the M1116B offers ten speeds.

The following components carry out the major functions within the M1116A Recorder Module.

Table 1-13 Major Recorder Module (M1116A) Components

Component	Function
DC-to-DC Converter	Generates power for the digital circuitry and printing mechanisms.
Motor Control Circuits	Control the operation of the paper drive motor.
I/O Microcontroller	Manages the I/O operations for the module.
Print Microcontroller	Regulates print speed and contrast.
Random Access Memory	Provides storage for data accessed by the microcontrollers.
Paper Drive Motor	Feeds the paper through the printer.
Thermal Printhead	Provides the printing mechanisms for the recorder.

Block Diagram

Figure 1-25 shows the block diagram of the Recorder Module M1116A.

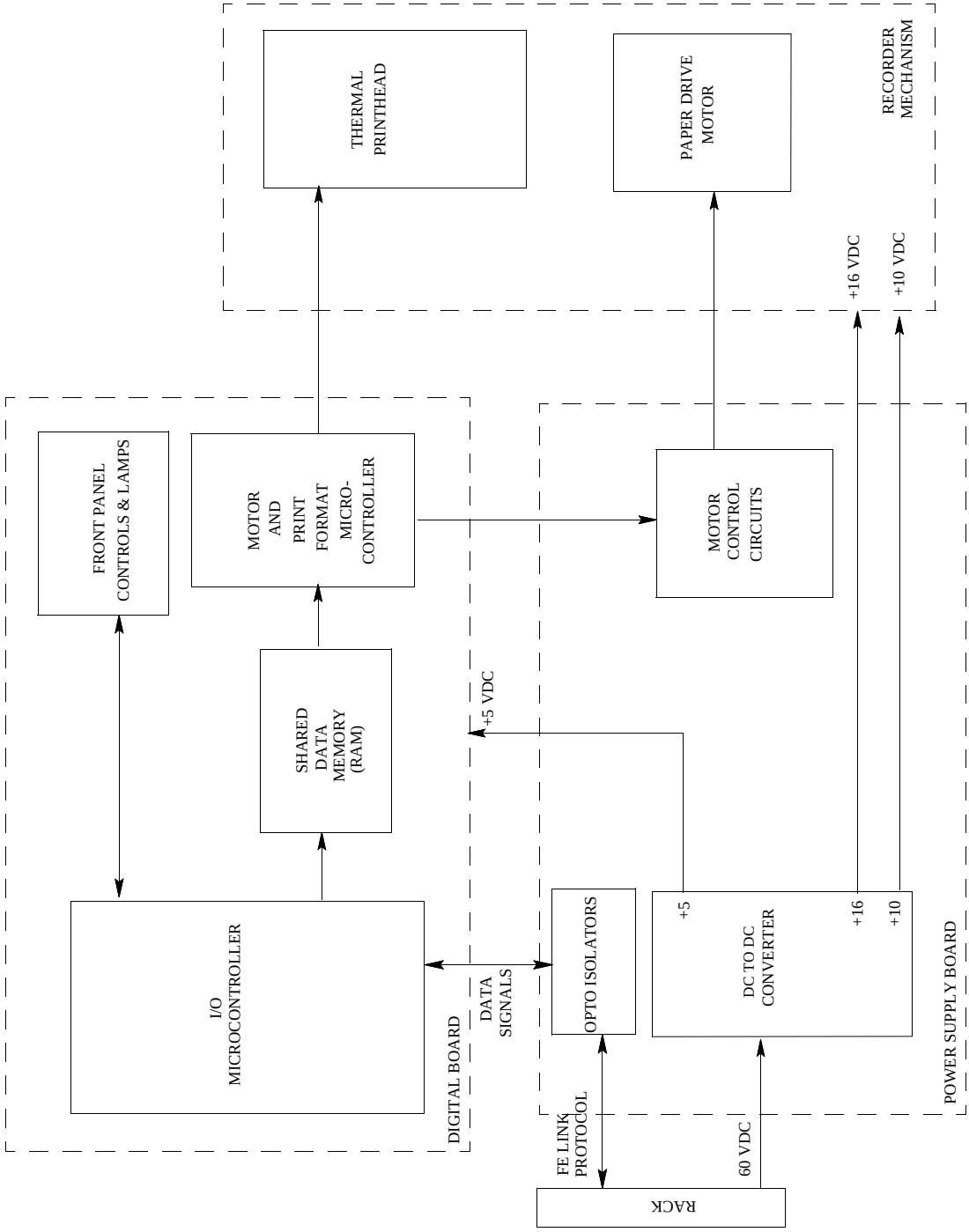

RECORDER MECHANISM
THERMAL PRINTHEAD
PAPER DRIVE MOTOR
+16 VDC
+10 VDC
FRONT PANEL CONTROLS & LAMPS
MOTOR AND PRINT FORMAT MICRO-CONTROLLER
MOTOR CONTROL CIRCUITS
SHARED DATA MEMORY (RAM)
+5 VDC
I/O MICROCONTROLLER
DIGITAL BOARD
DATA SIGNALS
OPTO ISOLATORS
DC TO DC CONVERTER
+5
+16
+10
POWER SUPPLY BOARD
FE LINK PROTOCOL
60 VDC
RACK

Figure 1-25 M1116A Recorder Module Block Diagram

Theory of Operation

The functional components for the M1116A Recorder Module are contained on two printed circuit boards and in a recorder mechanism unit. The circuit boards are referred to as the power supply board and the digital board. The power supply board runs parallel to the back of the module. It contains a DC-to-DC converter, optical isolators, and motor control circuits for the paper drive motor. The digital board runs along the length of the module from the front panel to the power supply board. It contains two microcontrollers, a shared data RAM, and the front panel controls and lamps.

Signal processing through the module proceeds as follows:

Power Supply Board: Power and data signals enter the module from the monitor through the power supply board. The DC-to-DC converter converts the 60V DC from the front-end rack into +5V DC for the digital circuits and +15V DC for the motor drivers and printhead. Data signals from and to the rack are passed through infrared optical isolators for noise suppression.

Digital Board: Signals enter the board through the I/O Microcontroller's built-in serial data port. The serial data link between the monitor and Recorder Module operates asynchronously on two separate lines, providing full duplex communication at a 500 KB baud rate. The I/O Microcontroller interprets messages from the monitor, and sends back identification and status messages through the power supply board. The I/O Microcontroller is responsible for:

- receiving and responding to commands and data from the monitor
- sensing and reporting on the state of the control keys and switches
- converting waveforms and annotation into a format suitable for driving the printhead

The user controls, door-open switch, and paper-out sensor are mounted directly on the digital board near the front of the module. The paper-out sensor is an optical device that aims an infrared beam at the paper as it passes around the paper drive roller. When paper is present, the infrared light is strongly reflected back to a phototransistor connected to the I/O Microcontroller.

The I/O Microcontroller translates waveform and annotation data into row and column format, merges the data into a matrix that represents the dot pattern to be printed, and writes the matrix to the dual-port RAM. The RAM is maintained as a rotating buffer, so that memory locations can be reloaded as soon as a column of dots is sent to the printhead.

The Motor and Print Format Microcontroller sends each column of dots to the thermal printhead at 2 msec intervals through its built-in serial communications port and directs reloading of the printhead's shift register at a 3MHz clock rate. The Motor and Print Format Microcontroller maintains uniform print contrast by monitoring the printhead's temperature and watt consumption, and modulating the strobe width that is applied to the dots during printing. The Motor and Print Format Microcontroller

also sends instructions to the motor control circuits on the power supply board to regulate the paper drive motor speed.

Recorder Mechanism: This unit contains the thermal printhead and paper drive motor. Both components receive signals generated by the Motor and Print Format Microcontroller on the digital board.

The printhead assembly contains a column of 384 heater elements for printing the dots, oriented perpendicular to the direction of paper travel. It also contains a 384-stage-shift register, which serves as a data-holding buffer for one column of dots to be printed. Each heater element has its own driver circuit. When a column of data is received from the Motor and Print Format Microcontroller, the shift register is loaded; the dots are printed as their respective heater elements are turned on. Print density is controlled by the width of the strobe applied to each dot and by the temperature of the printhead.

The signals to the paper drive motor are sent through the motor control circuits on the power supply board. These circuits regulate the speed of the paper motion.

Altering Power Consumption: During frequency response tests, or when the recorded waveform exhibits rapid vertical transitions, the Recorder Module may decrease its power consumption by reducing the intensity of the thermal array head. When this occurs, a lighter waveform segment may appear in brief intervals on the recorder output strip. An example of such output is shown in Figure 1-26.

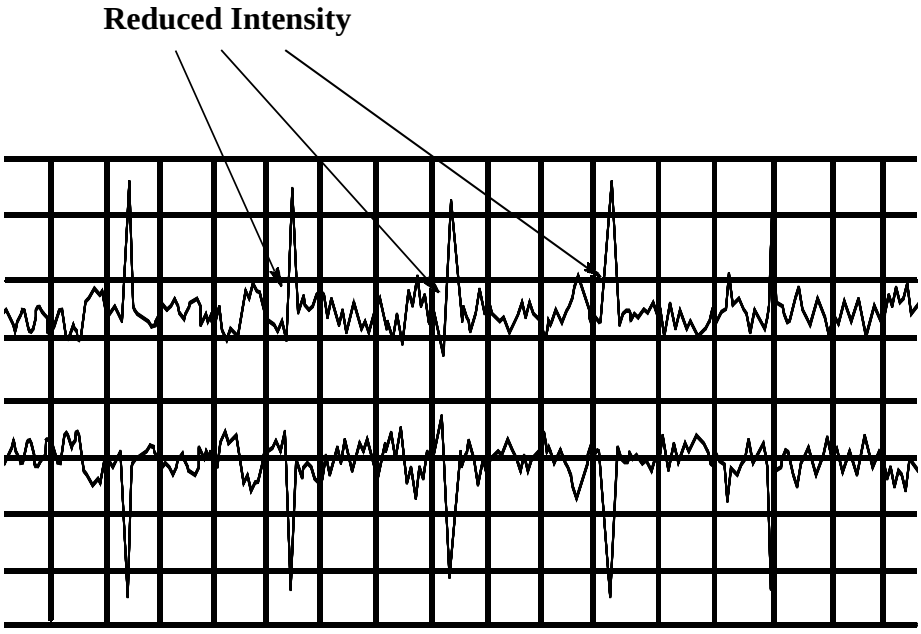


Figure 1-26 Example of Reduced Intensity Waveform Segments

Recorder Module Features

Figure 1-27 shows the user controls for the module.

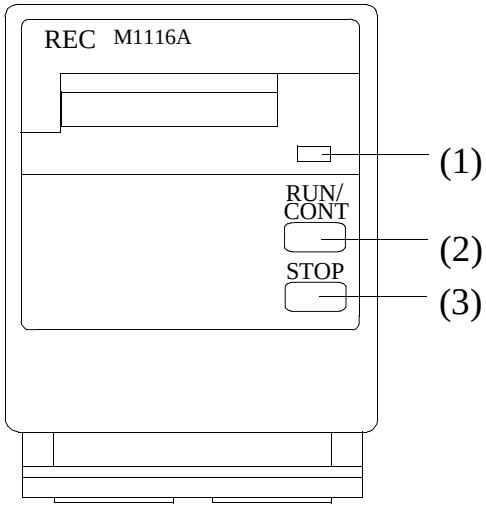


Figure 1-27 Recorder Module Controls and Connectors

User Controls

The M1116A and M1116B Recorder Modules have the same controls.

1 **Continue Indicator:** An LED that is lit steadily during continuous recordings. It blinks twice when the module is first plugged in, indicating that the recorder self-test has been completed successfully.

2 **Run/Continue Key:** If the recorder is not running, it starts a time-delayed recording. If the recorder is running, it makes the current recording continuous, if possible.

3 **Stop Key:** Stops the current recording.

Recordings

The M1116A Recorder can produce several types of recordings:

- delayed
- real-time
- monitoring procedure

- vital signs
- alarm -- generated automatically when clinical criteria are violated.

Recordings are made on 50mm-wide recording strip paper.

Delayed recordings are recordings of waveforms whose measurement began before the recording was initiated. For example, if a waveform is being displayed on the monitor, a user can set the recording to start from an earlier time. Delayed recordings run for a preset time. They can be initiated manually by the user, or automatically when an alarm occurs.

Real-time recordings begin immediately at the time they are requested and are stopped manually. They can also be preset to begin recording pre-selected waveforms at a specific time. For pre-selected waveforms, three separate recording modes (A, B, and C) can be configured. A preset recording begins printing when the preconfigured recording key is pressed.

Monitoring procedure recordings can be made during cardiac output and pulmonary artery wedge pressure measurements and during ST analysis. They are accomplished with soft keys during the procedures.

Vital sign recordings can be initiated automatically by an NBP measurement, by an internal timer in the monitor, or by a user. The NBP measurements can be taken by the NBP plug-in module or by an NBP monitor connected through VueLink. Vital sign recordings are made only at the bedside by the M1116A and M1116B Recorder Modules; they are not re-routed to a central recorder if the bedside recorder is not available.

Alarm recordings are a type of delayed recording. They include waveform information from before the alarm was initiated, so clinicians can see the change in the patient's condition. When a patient goes into an alarm condition, an alarm recording is generated automatically according to the monitor's configuration. Settings for alarm severity level, as well as for enabling or disabling alarm recordings, are possible for each individual parameter.

Recorder Module Exercises (M1116A)

1. The M1116A Recorder Module can write ____ different waveforms at ____ speeds.

2. The two printed circuit boards in the module are referred to as the _____ board and the _____ board.

3. Which component supplies the power for the digital circuits and recorder mechanism?

   a. DC-to-DC converter
   b. front-end rack
   c. motor control circuits
   d. I/O Microcontroller

4. Which component converts the waveforms and annotation into dot matrix for printing?

   a. DC-to-DC converter
   b. I/O Microcontroller
   c. Motor and Print Format Microcontroller
   d. motor control circuits

5. The recorder mechanism consists of the _____ and _____ components.

6. Which type(s) of recording can be set to begin automatically?

   a. delayed
   b. delayed and vital sign
   c. delayed, real-time, and vital sign
   d. delayed, real-time, monitoring procedure, and vital sign

Answers
1. three, eight
2. power supply, digital
3. a
4. b
5. thermal printhead, paper drive motor
6. b

Recorder Module (M1116B)

Description

The M1116B Recorder Module provides thermal array recording capability for the Philips patient monitoring family, including the V24/V26. Like the M1116A Recorder Module, it can write up to three overlapped waveforms and three lines of annotation. The M1116B has several additional capabilities not offered by the M1116A. It provides ten recording speeds, two more than the M1116A. It can also provide oxygen-cardiorespirogram recordings.

The following components carry out the major functions within the M1116B Recorder Module.

Table 1-14 Major Recorder Module (M1116B) Components

Component	Function
DC-to-DC Converter	Generates power for the digital circuitry and printing mechanisms.
Motor Control Circuits	Control the operation of the paper drive motor.
Microcontroller	Manages the I/O and print operations for the module.
Random Access Memory	Provides storage for data accessed by the microcontrollers.
Paper Drive Motor	Feeds the paper through the printer.
Thermal Printhead	Provides the printing mechanisms for the recorder.

Block Diagram

Figure 1-28 shows the block diagram of the Recorder Module M1116B.

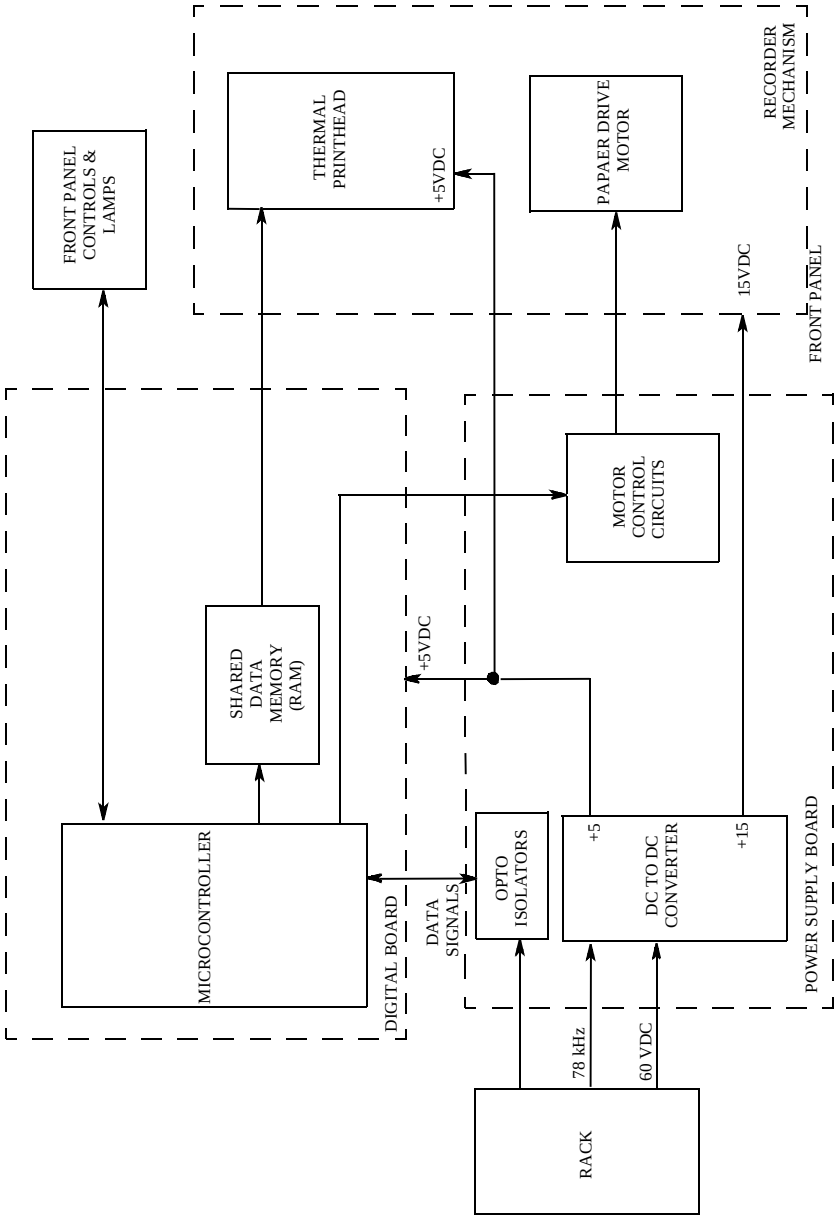


Figure 1-28 M1116B Recorder Module Block Diagram

Theory of Operation

The M1116B Recorder Module contains a power supply circuit board, a digital circuit board, and a recorder mechanism unit. The components for the M1116B Module are slightly different from those of the M1116A. The power supply board contains a DC-to-DC converter, optical isolators, and motor control circuits for the paper drive motor. The digital board contains only one microcontroller and a single-port RAM. The front panel controls and lamps are mounted directly on the board, as they are on the M1116A.

Signal processing through the module proceeds as follows:

Power Supply Board: Power and data signals enter the module from the monitor through the power supply board. The DC-to-DC converter converts the 60V DC from the front-end rack into +5V DC for the digital board and +15V DC for the motor drivers and printhead. Data signals from and to the rack are passed through infrared optical isolators for noise suppression.

Digital Board: Signals enter the board through the single microcontroller's built-in serial data port. The serial data link between the monitor and Recorder Module operates asynchronously on two separate lines, providing full duplex communication at a 500 KB baud rate. The microcontroller interprets messages from the monitor and sends back identification and status messages through the power supply board. The microcontroller is responsible for:

- receiving and responding to commands and data from the monitor
- sensing and reporting on the state of the control keys and switches
- converting waveforms and annotation into a format suitable for driving the printhead

The user controls, door-open switch, and paper-out sensor are mounted directly on the digital board near the front of the module. The paper-out sensor is an optical device that aims a pulsed infrared beam at the paper as it passes around the paper drive roller. When paper is present, the infrared light is strongly reflected back to a phototransistor connected to the microcontroller. The M1116B Module has an infrared sensing circuit to determine if the paper-loading door is open. If the door is closed, a tab on the door interrupts the light beam. Software routines control the infrared beam for the optical interrupt. The door-open sensor is absent from the M1116A.

The microcontroller translates waveform and annotation data into a row and column format, merges the data into a matrix that represents the dot pattern to be printed, and writes the matrix to the RAM. The RAM is maintained as a rotating buffer so that memory locations can be reloaded as soon as a column of dots is sent to the printhead. The microcontroller maintains uniform print contrast by monitoring the printhead's temperature and watt consumption, and modulating the strobe width that is applied to the dots during printing. The microcontroller also sends signals to the motor control circuits for regulating the paper drive motor speed.

Recorder Mechanism: This unit contains the thermal printhead and paper drive motor. Both components receive signals generated by the microcontroller on the digital board.

The printhead assembly contains a column of 384 heater elements for printing the dots, oriented perpendicular to the direction of paper travel. It also contains a 384-stage-shift register, which serves as a data-holding buffer for one column of dots to be printed. Each heater element has is own driver circuit. When a column of data is received, the shift register is loaded; the dots are printed as their respective heater elements are turned on. Print density is controlled by the width of the strobe applied to each dot and by the temperature of the printhead.

The signals to the paper drive motor are sent through the motor control circuits on the power supply board. These circuits regulate the speed of the paper motion.

Recorder Module Features

Figure 1-29 shows the user controls for the M1116B Module.

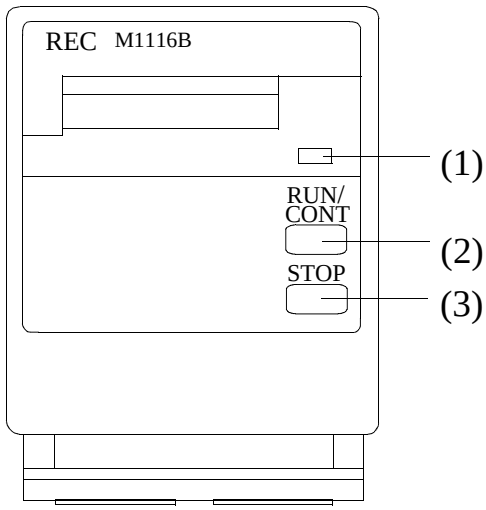


Figure 1-29 Recorder (M1116B) Module Controls

User Controls

The M1116A and M1116B Recorder Modules have the same user controls.

1 **Continue Indicator:** An LED that is lit steadily during continuous recordings. It blinks twice when the module is first plugged in, indicating that the recorder self-test has been completed successfully.

2 **Run/Continue Key:** If the recorder is not running, it starts a time-delayed recording. If the recorder is running, it makes the current recording continuous, if possible.

3 **Stop Key:** Stops the current recording.

Recordings

The M1116B Recorder can produce the same recordings as the M1116A Module, plus the additional type:

- delayed
- real-time
- monitoring procedure
- vital signs
- alarm -- generated automatically when clinical criteria are violated
- oxygen-cardiorespirogram (oxyCRG) -- oxyCRG recordings cannot be made by the M1116A Module.

Recordings are made on 50mm-wide recording strip paper.

Delayed recordings are recordings of waveforms whose measurement began before the recording was initiated. For example, if a waveform is being displayed on the monitor, a user can set the recording to start from an earlier time. Delayed recordings run for a preset time. They can be initiated manually by the user, or automatically when an alarm occurs.

Real-time recordings begin immediately at the time they are requested and are stopped manually. They can also be preset to begin recording pre-selected waveforms at a specific time. For pre-selected waveforms, three separate recording modes can be configured. A preset recording begins printing when the preconfigured recording key is pressed.

Monitoring procedure recordings can be made during cardiac output and pulmonary artery wedge pressure measurements, and during ST analysis. They are accomplished with soft keys during the procedures.

Vital sign recordings can be initiated automatically by an NBP measurement, by an internal timer in the monitor, or by a user. The NBP measurements can be taken by the NBP plug-in module or by an NBP monitor connected through VueLink. Vital sign recordings are made only at the bedside by the M1116A and M1116B Recorder Modules; they are not re-routed to a central recorder if the bedside recorder is not available.

Alarm recordings are a type of delayed recording. They include waveform information from before the alarm was initiated, so clinicians can see the change in the patient's condition. When a patient goes into an alarm condition, an alarm recording is generated automatically according to the monitor's configuration. Settings for alarm severity level, as well as for enabling or disabling alarm recordings, are possible for each individual parameter.

OxyCRG recordings are delayed recordings that begin six minutes prior to the most recent data on the screen. The time delay enables the clinician to have a printout of events leading up to the current situation. Recordings can be requested manually or configured as alarm recordings. In an alarm recording, six minutes of pre-alarm data and two minutes of post-alarm data are produced. When a recording is stopped, the most recent six minutes of patient data are not recorded. The oxyCRG is recorded in

three distinct non-overlapping channels on the strip. Three speeds are possible for recording the data.

Recorder Module Exercises (M1116B)

1. The M1116B Recorder Module can write ____ different waveforms at ____ speeds.

2. The two printed circuit boards in the module are referred to as the _____ board and the _____ board.

3. Which component supplies the power for the digital circuits and recorder mechanism?

a. DC-to-DC converter
b. opto-isolators
c. motor control circuits
d. microcontroller

4. Which component converts the waveforms and annotation into a dot matrix for printing?

a. DC-to-DC converter
b. microcontroller
c. thermal printhead
d. motor control circuits

5. The M1116B provides _____ that is not available on the M1116A.

Answers
1. three, ten
2. power supply, digital
3. a
4. b
5. ten recording speeds (versus 8) or
oxygen-cardiorespirogram (OxyCRG) recordings

Data Transfer Module Concepts

Data Transfer Module

Description

The M1235A Data Transfer Module provides data transfer capability for the CMS, including the Anesthesia CMS, the Component Transport System, and V24/V26. It is designed to transfer a patient's vital signs and demographics between monitors in a range of critical care environments. The module retains patient information for an hour or longer when not plugged into a monitor.

Components

The following components carry out the major functions within the module.

Table 1-15 Major Components

Component	Function
Power Supply	Generates power for the digital circuitry and LEDs.
Microcontroller	Manages the operation of the module.
Memory	Provides storage for data and instructions.
Back-Up Power Supply	Provides power for one hour or longer when the main power supply is unavailable.
Real-Time Clock	Tracks the time the module is removed from a monitor during data transfer.

Block Diagram

Figure 1-30 shows the block diagram of the Data Transfer Module M1235A.

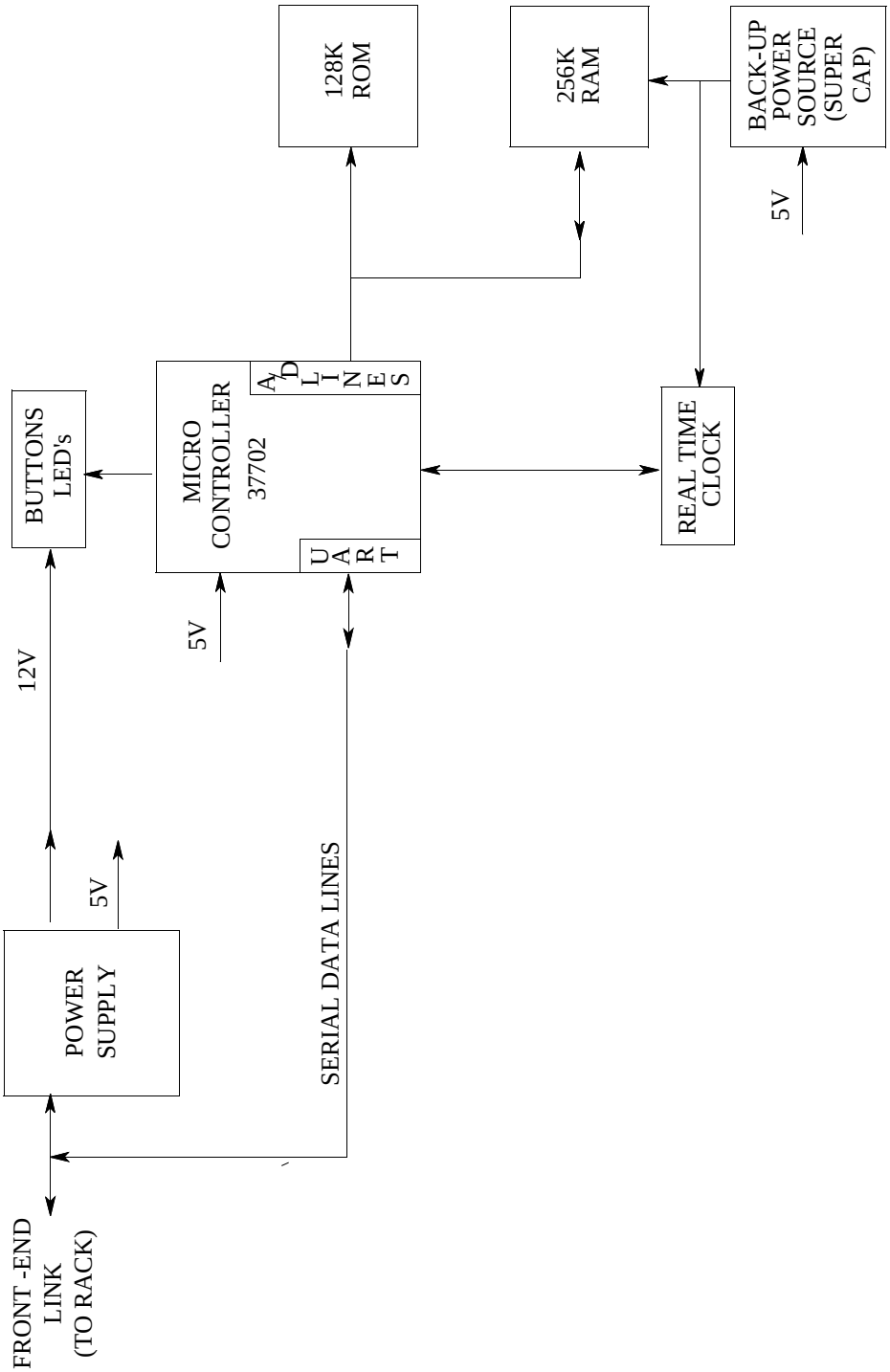

128K
ROM
256K
RAM
BACK-UP
POWER
SOURCE
(SUPER
CAP)
5V
BUTTONS
LED's
MICRO
CONTROLLER
37702
ADDRESS
UART
REAL TIME
CLOCK
12V
5V
5V
SERIAL DATA LINES
POWER
SUPPLY
FRONT -END
LINK
(TO RACK)

Figure 1-30 Data Transfer Module Block Diagram

Theory of Operation

The module contains two circuit boards on one assembly; the boards are referred to as the front panel board and the main board. The front panel board consists of the indicator LEDs and control keys. The main board consists of the major functional components, which are described in more detail below.

Power Supply: The power supply receives 60V, synchronized to 78KHz from the front end link, and generates 5V and 12V unregulated. The 5V is regulated to provide power for the digital circuitry; the 12V unregulated drives the LEDs. Circuit ground throughout the Data Transfer Module is common for both power and digital circuitry.

Microcontroller: The 37702 microcontroller manages the operation of the Data Transfer Module. It has a 16MB address range, multiple configured I/O ports, and two UART ports that can be used in either asynchronous or synchronous mode. The microprocessor is responsible for:

- addressing the 256KB RAM and 128KB ROM in basic read and write cycles
- communicating in asynchronous serial mode to the monitor through the front-end link
- driving the LEDs, and receiving key pushes from the front panel
- accessing the serial RTC chip

Memory: The Data Transfer Module contains 256KB of RAM and 128KB of ROM. The RAM is implemented using two banks of 128 x 8 low-standby-power SRAM, which are specifically designed for low power consumption in battery back-up mode. When power is disconnected, the RAM goes into battery back-up mode, and its power supply is switched over to the back-up source. Program storage for the Data Transfer Module consists of one 128KB OTP ROM.

Back-Up Power Supply: The digital circuitry uses a 0.1F super capacitor to provide back-up power to the RAM and RTC. Back-up power is supplied whenever main power is unavailable, such as when power fails, the monitor is turned off, or the module is removed from the monitor for transfer. The back-up power supply charges in less than 20 seconds and provides at least one hour of data retention and RTC operation in back-up mode.

Real-Time Clock: The RTC keeps track of how long the module is disconnected from a monitor for data transfer. The RTC is located in a semi-isolated area of the main board to ensure low noise. The RTC oscillator timing pulse, which is configured to 0.1Hz, is used as an interrupt to the microcontroller to measure the RTC for accuracy. If the pulses fall outside of the tolerance limit, an error is flagged.

Data Transfer Module Features

Figure 1-31 shows the user controls and connector for the module. Two versions of the front panel are available: universal and English. The parts are described following the figure.

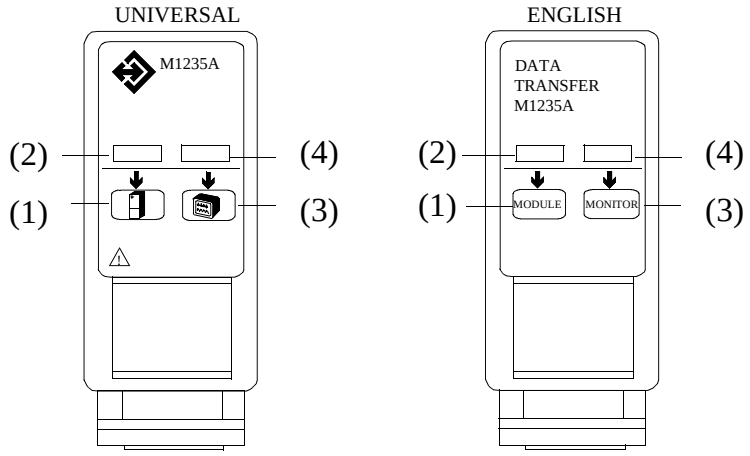


Figure 1-31 Data Transfer Module Controls

User Controls

1 **Transfer to Module Key --** A single-press key used to transfer data from the monitor to the module.

2 **Transfer to Module Indicator --** A green LED that indicates several functions. It is lit steadily when a Data Transfer setup screen is active. It blinks rapidly when initial data are being transferred to the module. It blinks slowly when continuous updates are being transferred to the module.

3 **Transfer to Monitor Key --** A single-press key used to transfer data from the module to the monitor**.**

4 **Transfer to Monitor Indicator --** A green LED that is lit steadily when a Data Transfer setup screen is active. It blinks rapidly when blocks of data are being transferred to the monitor.

Safety

The Data Transfer Module complies with UL-544, IEC 601-1, and CSAC22.2 No. 125.

Capabilities

The Data Transfer Module transfers patient demographics and up to 24 hours of trend data between patient monitors. It can transfer up to 32 continuously monitored vital signs from one monitor to another. Vital signs transferred to the module from a monitor are updated continuously.

Data transfers can be accomplished in as few as 30 seconds. The module provides a minimum of one hour of back-up power when removed from a monitor to transfer data. Data in the module are erased after transfer to the monitor is complete.

Data Transfer Module Exercises

1. The Data Transfer Module transfers data between the CMS Release E, Component Transport System Release E, Anesthesia CMS, and _____.

2. Which types of data are transferred by the module?

a. patient demographics only
b. trends only
c. vital signs only
d. a and c
e. a, b, and c

3. Which two components reside on a separate circuit board from the other components?

a. LEDs and control keys
b. microcontroller and memory
c. back-up power supply and clock
d. power supply and front-end-link

4. The module contains _____ kB of RAM and _____ kB of ROM. The module can transfer patient trends for up to _____ hours.

Answers
1. V24 and V26 Patient Monitors
2. e
3. a
4. 256 kB RAM, 128 kB ROM, 24 hours

Chapter 2 Advanced Plug-In Modules

Introduction

This chapter covers the advanced set of plug-in parameter modules used by Philips' patient monitoring system and the measurement principles on which they are based.

The categorization of "advanced" modules is based on the complexity of their data-processing functions rather than on the ease or difficulty of taking the measurements. Engineers who maintain and repair the equipment may want to familiarize themselves with the basic modules before moving on to the more advanced ones.

Goals

After successfully completing this chapter, you should be able to:

- Describe the physiologic measurements that can be acquired and processed by Philips' advanced plug-in parameter modules.
- Explain how the Philips' plug-in modules acquire and process measurements.

Objectives

In order to meet the chapter's goal, you should be able to:

- Define each of the physiologic measurements.
- State the principle by which each measurement is derived.
- Recognize the forms in which the data for each measurement are represented.
- Identify the criteria and influencing factors which relate to the proper acquisition of the measurement.
- Describe the methods, components and mechanisms by which the measurement's electrical signals are processed by the corresponding module.
- Identify and describe the features and accessories of the plug-in module.

Topics

This chapter contains the following topics:

Chapter Topics

Measurements and Modules	Page
Invasive Blood Pressure Measurement	2-3
Invasive Blood Pressure Module (M1006A)	2-6
Invasive Blood Pressure Module (M1006A/Option #C01)	2-11
Invasive Blood Pressure Module (M1006B)	2-16
CO2 Respiratory Gas Measurement	2-20
CO2 Respiratory Gas Module (M1016A)	2-23
Sidestream CO2 Module (M1015A)	2-28
FIO2 Respiratory Measurement	2-33
FIO2 Module (M1017A)	2-35
tcpO2/tcpCO2 Measurement	2-40
tcpO2/tcpCO2 Module (M1018A)	2-43
SvO2 Blood Gas Measurement	2-50
SvO2 Module (M1021A)	2-52
Blood Analysis Measurement	2-58
Blood Analysis Module (M1022A)	2-62
VueLink Module	2-68
EEG Measurement	2-74
EEG Module	2-79
BIS Measurement	2-86
BIS Module	2-93

Invasive Blood Pressure Module Concepts

Invasive Blood Pressure Measurement

Description

Blood pressure is the measured force of the movement of a patient's blood within the blood vessels. The first measurement registers ventricular contraction and the second measurement registers closure of the aortic valve. When the measuring device is in the patient's blood stream, the measurement is called an invasive blood pressure.

This information indicates the status of the patient's overall cardiac condition.

Concepts

Blood Pressure concepts important to this section are:

- **Normal Blood Pressure**- The blood's pressure within the systemic arterial system
- **Systolic Pressure**- The *greatest* pressure of the blood against the blood vessel walls following ventricular contraction.
- **Diastolic Pressure**- The *least* pressure of the blood against the blood vessel walls following closure of the aortic valve.
- **Pulse Pressure**- The *difference* between the systolic and diastolic readings. This is the range of the pressure in the arteries.
- **Mean Arterial Pressure**- The average pressure pushing blood through the circulatory system.

Measurement Principle

When measuring invasive blood pressure, the force of movement of the blood in the patient's systemic arterial system is transported by a fluid column in the pressure line to the transducer. This pressure causes an electrical signal to be generated which is then amplified to display the pressure wave and the numerics for the systolic, diastolic, and mean pressure values.

Measurement Acquisition

An invasive blood pressure measurement is collected through a pressure transducer that is connected to a pressure line by means of a catheter which is invasively placed in the patient's blood stream.

Measurement Output

Blood pressure is depicted as a pressure wave with the numerics for systolic, diastolic, and mean pressure values. The blood pressure shows the cycles of contraction and release within the heart and the resultant pressure that is generated to move the blood through the vessels.

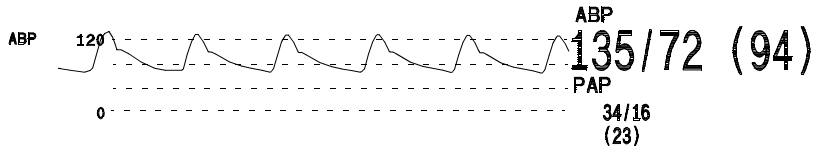


Figure 2-1 An Example of a Typical Invasive Pressure Wave

Criteria for Proper Measurement

Factors affecting accurate measurement of invasive blood pressure are:

- Proper connection between the pressure transducer, pressure line, and patient catheter.
- Systolic pressure readings in lower extremities are usually higher than readings in higher extremities.
- Moving from a reclining position to a standing position can cause the systolic pressure to fall and the diastolic pressure to rise slightly.
- The positioning of both the patient and the pressure transducer can influence the pressure measurement. It is normal practice to position the transducer at heart level (4th intercostal space and the midaxillary line: known as phlebostatic axis) and to zero the system to compensate for the static and atmospheric pressure.

Plug-In Modules

Three of Philips' plug-in modules can measure invasive blood pressure: the PRESS Module (M1006A), PRESS Module (M1006B) and the PRESS Module (M1006A Option C01).

Invasive Blood Pressure Measurement Exercises

1. Invasive blood pressure measurement is an indication of:

   a. the force of a patient's blood within the blood vessels
   b. the amount of oxygen present in the blood vessels
   c. the force of CO_2 exerted within the blood vessels

2. Invasive blood pressure measurement uses a technique based on:

   a. absorption of infrared radiation
   b. temperature of measurement being collected
   c. blood force being transported by a fluid column in the pressure line to a transducer

3. Invasive blood pressure measurement is displayed as:

   a. a blinking light
   b. percentage amount
   c. waveform with numerics

4. What factor can influence the accurate measurement of invasive blood pressure?

   a. temperature of patient's blood
   b. amount of dissolved Oxygen in the patient's blood
   c. going from a reclining position to a standing position

Answers
1. a
2. c
3. c
4. c

Invasive Blood Pressure Module (M1006A)

Description

The Pressure (PRESS) M1006A Module is an invasive blood pressure measurement parameter unit. It is designed to be used with adult, pediatric, or neonatal patients in a range of Critical Care environments.

Measurements

The PRESS M1006A Module produces a real-time waveform, together with the pulse rate and numeric readings for the systolic, diastolic, and mean blood pressure values.

Components

The PRESS Module M1006A consists of the following major functional components:

Table 2-1 Major PRESS Module (M1006A) Components

Component	Description
Input Protection Network	Protects the module from extraneous signals, i.e., defibrillation and electro surgery.
Input Amplifier	Amplifies the signal before it is sent to the microcontroller.
Demodulators	Demodulates the amplifier carrier signal before it is input1 to the low pass filter.
Zeroing/Calibration Test	To compensate for an input pressure offset, an offset compensation signal is generated by the Digital-to-Analog converter. The Digital-to-Analog converter also generates the calibration staircases (CAL2) for the recorder calibration and the test signal.

Block Diagram

Figure 2-2 shows the block diagram of the recorded patient signal flow through the PRESS Module M1006A.

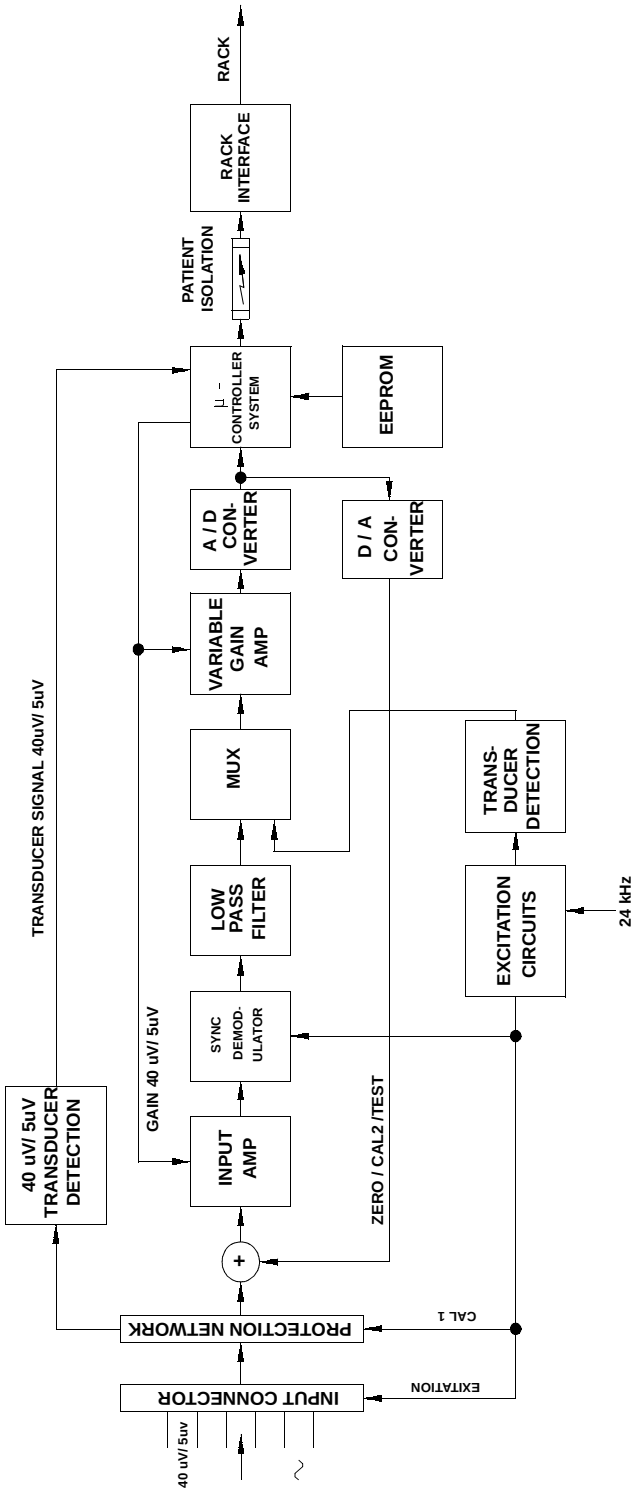


Figure 2-2 M1006A Invasive Pressure Module Block Diagram

Theory of Operation

There are four major sections that the electrical signal must pass through in order to reach the Monitor interface:

1 The amplitude modulated signal from the patient is received electrically through the input connector from the transducer connected to the patient's catheter.

2 The signal then gets passed through the Input Protection Network where extraneous signals are filtered out. This network provides protection against defibrillation spikes. The signal, together with the zero compensation signal, then travels from the Input Protection Network to the input amplifier.

3 The signals are received from the Input Protection Network. The sensitivity of the transducer is corrected by the 40µV/5µV Transducer Sensitivity circuitry and is then transmitted to the microcontroller. The gain of the Input Amplifier for either 40µV or 5µV sensitivity is set by the microcontroller.

The amplifier carrier signal is synchronously demodulated before being input to the lowpass filter. The filter is then optimized by a variable amplifier before being digitized by the Analog-to-Digital converter.

To compensate for input pressure offset (caused by static or atmospheric pressure at the pressure transducer) an offset compensation signal is generated by the Digital-to-Analog converter. The offset values are stored in an EEPROM. The Digital-to-Analog converter also generates the calibration staircases (CAL2) for the recorder calibration and the test signal. Both the calibration signal and the test signal are generated on user request.

4 The signal is then passed through the patient isolation to the rack interface and then to the receiving rack.

PRESS M1006A Features

Figure 2-3 shows the user controls and connectors for the PRESS Module M1006A. Refer to this figure for the User Controls and Connector descriptions.

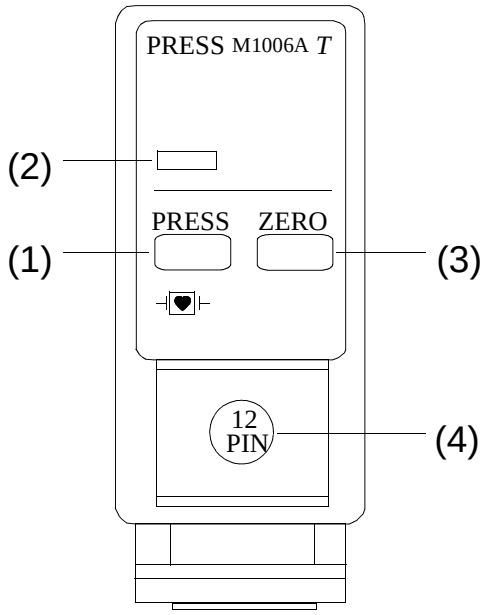


Figure 2-3 PRESS Module (M1006A) Controls and Connectors

User Controls

1 **Pressure Setup Key**- a single-press key which is used to enter the Pressure Setup Screen.

2 **Pressure Setup Indicator** - a green LED light which is lit when user is in the Pressure Setup Screen.

3 **Zero Key** - a single-press key which is used to zero the transducer without using the master display controls.

Connectors

4 The PRESS M1006A uses a standard **12-pin connector** with a pressure transducer that has a sensitivity of either 5µV (+/- 10%) or 40µV (+/- 40%).

Safety

To ensure the safety of the patient, the patient applied parts are isolated from ground by optical isolators and a transformer. In addition, the entire module is encapsulated in plastic.

This module complies with UL544, IED-601-1, CSA C22.2 No. 125. Patient leakage current is less than 10µA at 120V/60Hz.

It has an isolated patient connection to *Class I* protection, Type *Cardiac Floating* (CF).

There is also protection against damage from defibrillation and electro surgery.

PRESS M1006A Module Exercises

1. The PRESS M1006A Module measures:

   a. cardiac output
   b. invasive blood pressure
   c. blood oxygen concentration level

2. The PRESS M1006A Module produces a waveform along with all but:

   a. systolic numeric value
   b. instantaneous CO_2 numeric value
   c. diastolic numeric value

3. The PRESS M1006A Module Input Amplifier performs which of the following functions?

   a. amplifies the signal before it is sent to the microcontroller
   b. demodulates the signal before it is sent to the microcontroller
   c. protects the module from extraneous signals

4. The PRESS M1006A Module has all but the following user controls:

   a. Zero Key
   b. Pressure Setup Indicator
   c. CAL Indicator

Answers
1. b
2. b
3. a
4. c

Invasive Blood Pressure Module (M1006A/Option #C01)

Description

The PRESS M1006A/Option #C01 Module is an invasive blood pressure measurement parameter unit. It is designed to be used with adult, pediatric, or neonatal patients in a range of Critical Care environments.

Measurements

The PRESS M1006A/Option #C01 Module produces a real-time waveform, together with the pulse rate and numeric readings for the systolic, diastolic, and mean blood pressure values.

This module provides an analog pressure output signal for use with intra-aortic balloon pumps (IABP).

Components

The PRESS Module M1006A/Option #C01 consists of the following major functional components:

Table 2-2 Major PRESS Module (M1006A Option #C01) Components

Component	Description
Input Protection Network	Protects the module from extraneous signals, i.e., defibrillation and electro surgery.
Input Amplifier	Amplifies the signal before it is sent to the Microcontroller.
Analog Output Jack	This 1/4 inch phone jack contains three terminals: tip, ring, and sleeve. Tip provides the analog pressure output signal. Ring and sleeve are connected to analog ground.
Demodulator	Demodulates the carrier signal.
Zeroing/Calibration Test	To compensate for an input pressure offset, an offset compensation signal is generated by the Digital-to-Analog converter. The Digital-to-Analog converter also generates the calibration staircases (CAL2) for the recorder calibration and the test signal.

Block Diagram

Figure 2-4 shows the block diagram of the patient's recorded signal flow through the PRESS M1006A/Option #C01 Module.

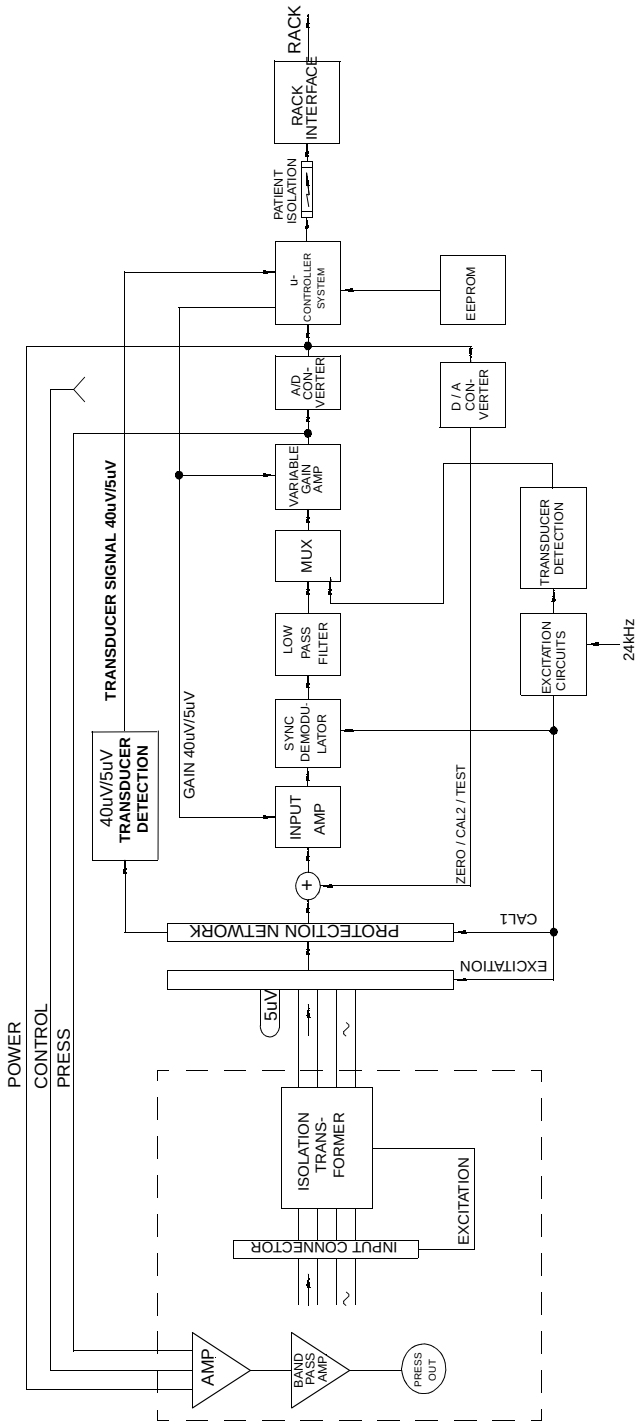


Figure 2-4 M1006A Invasive Pressure Module Option #C01 Block Diagram

Theory of Operation

There are four major sections that the electrical signal must pass in order to reach the Monitor interface:

1 The amplitude modulated signal from the patient is electrically received through the input connector from the 5µV/V/mmHg transducer connected to the patient's catheter. Only 5µV/V/mmHg transducers may be used with this module.

2 The signal then gets passed through the Input Protection Network where extraneous signals are filtered out. This network provides protection against defibrillation spikes. The signal then goes from the protection network to the Input Amplifier.

3 The signals are received from the Input Protection Network. The sensitivity of the transducer is corrected by the 5µV Transducer Sensitivity circuitry and transmitted to the microcontroller. The gain of the Input Amplifier for a 5µV sensitivity is set by the microcontroller.

The amplifier carrier signal is synchronously demodulated before being input to the lowpass filter. The filter is then optimized by a variable amplifier before being digitized by the Analog-to-Digital converter.

To compensate for input pressure offset (caused by static or atmospheric pressure at the pressure transducer) an offset compensation signal is generated by the Digital-to-Analog converter. The offset values are stored in an EEPROM. The Digital-to-Analog converter also generates the calibration staircases (CAL2) for recorder calibration and the test signal. Both the calibration signal and the test signal are generated on user request.

4 The signal is then passed through the patient isolation to the rack interface and then to the receiving rack.

PRESS M1006A/ Option #C01 Module Features

The features (User Controls, Connectors, Safety, and Accessories) for the PRESS M1006A/Option #C01 Module are the same as those for the PRESS M1006A Module with the exception of the analog output jack.

Figure 2-5 shows the user controls and connectors for the PRESS M1006A/Option #C01 Module. Refer to this figure for the User Controls and Connector descriptions.

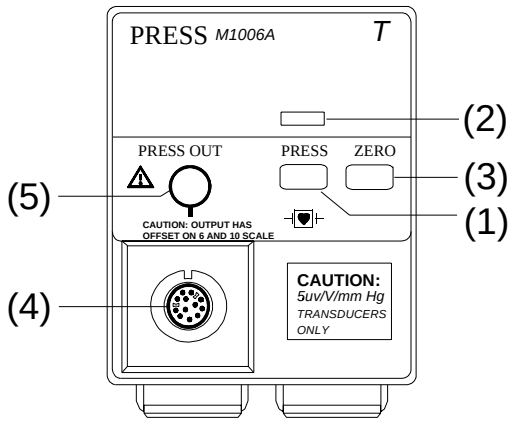


Figure 2-5 PRESS Module (M1006A Option #C01) Controls and Connectors

User Controls

1 **Pressure Setup Key**- a single-press key which is used to enter the Pressure Setup Screen.

2 **Pressure Setup Indicator** - a green LED light which is lit when user is in the Pressure Setup Screen.

3 **Zero Key** - a single-press key which is used to zero the transducer without using the master display controls.

Connectors

4 The PRESS M1006A #C01 uses a standard **12-pin connector** with a pressure transducer that has a sensitivity of 5µV (+/- 10%).

5 **Analog Output Jack**: This is standard 1/4 inch phone jack, used to provide analog signals to an intra-aortic balloon pump. Philips recommends that a molded phone plug cable (Product Number M1181A-#A62) be used with this output jack.

PRESS M1006A/ Option #C01 Module Exercises

1. What does the PRESS M1006A/Option #C01 Module Measure?

   a. CO_2 Output
   b. Invasive Blood Pressure
   c. Cardiac Output

2. What component of the PRESS M1006A/Option #C01 Module provides the analog output signal?

   a. Analog Output Jack
   b. Analog-to-Digital Converter
   c. Microcontroller Unit

3. The PRESS M1006A/Option #C01 Module uses the following:

   a. 40 µV/V/mmHg transducers
   b. 40 µV/V/mmHg and 5µV/V/mmHg transducers
   c. 5 µV/V/mmHg transducers

Answers
1. b
2. a
3. c

Invasive Blood Pressure Module (M1006B)

Description

The PRESS M1006B Module is an invasive blood pressure measurement parameter unit. It is designed to be used with adult, pediatric, or neonatal patients in a range of Critical Care environments. It contains the same functionality of the M1006A except it has no 40 µV/V/ mmHg sensitivity.

Measurements

The PRESS M1006B Module produces a real-time waveform, together with the pulse rate and numeric readings for the systolic, diastolic, and mean blood pressure values.

Components

The PRESS Module M1006B consists of the following major functional components:

Table 2-3 Major PRESS Module (M1006B) Components

Component	Description
Input Protection Network	Protects the module from extraneous signals, i.e., defibrillation and electro surgery.
Analog-to-Digital Converter	Amplifies, filters, and digitizes the input signal.
Microcontroller Unit	Sets all control information.

Block Diagram

Figure 2-6 shows the block diagram of the patient's recorded signal flow through the PRESS M1006B Module.

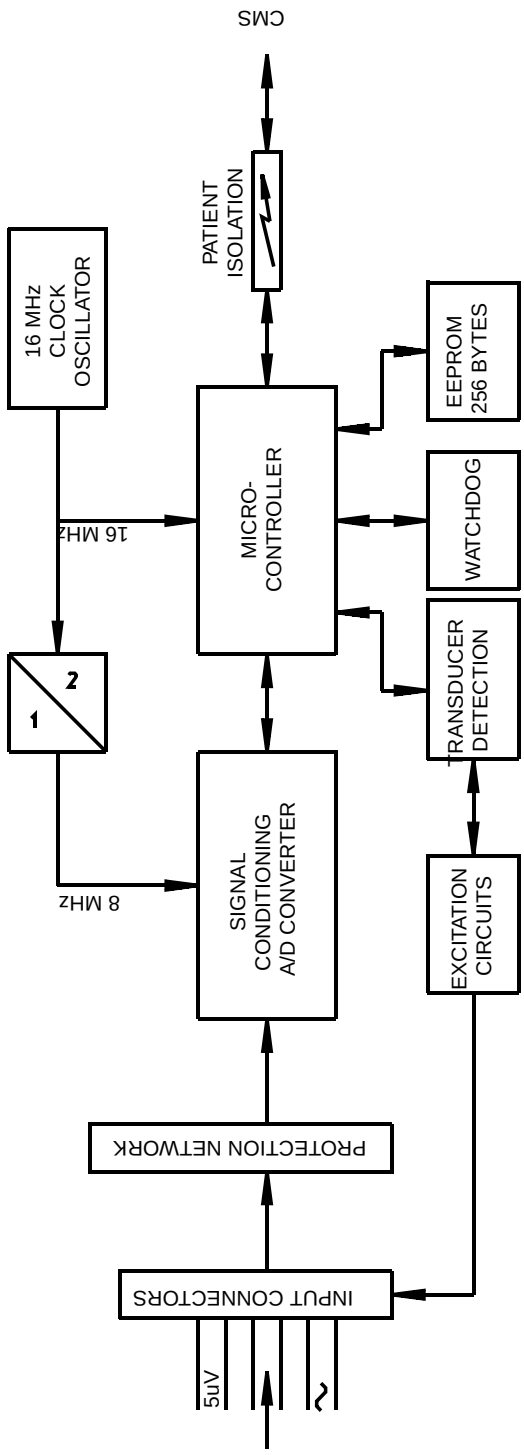


Figure 2-6 M1006B Invasive Pressure Module Block Diagram

Theory of Operation

There are four major sections that the electrical signal must pass through in order to reach the Monitor interface:

1 The amplitude modulated signal from the patient is received electrically through the input connector from the 5μV/V/mmHg transducer connected to the patient's catheter.

2 The signal then gets passed through the Input Protection Network, where extraneous signals are filtered out. This network provides protection against defibrillation spikes. The signal then travels from the protection network to the Analog-to-Digital Converter.

3 The signals are received from the Input Protection Network. The Analog-to-Digital Converter amplifies, filters, and digitizes the input signal and sends it to the Microcontroller Unit.

The Microcontroller sets all information needed by the converter and receives the converter's data. An EEPROM stores the information needed for correct converter setup. The timing of the Microcontroller is regulated by the clock oscillator.

4 The signal is then passed through the patient isolation to the rack interface and then to the receiving rack.

PRESS M1006B Module Features

The features (User Controls, Connectors, Safety, and Accessories) for the PRESS M1006B Module are the same as those for the PRESS M1006A Module except the M1006B has no 40 μV/V/ mmHg sensitivity.

PRESS M1006B Module Exercises

1. What does the PRESS M1006B Module Measure?

   a. Invasive Blood Pressure
   b. Cardiac Output
   c. CO_2 Output

2. What component of the PRESS M1006B Module sets all control information?

   a. Input Protection Network
   b. Analog-to-Digital Converter
   c. Microcontroller Unit

3. The PRESS M1006B Module uses the following:

   a. 40 µV/VmmHg transducers
   b. 5 µV/VmmHg transducers
   c. 40 µV/VmmHg and 5µV/VmmHg transducers

Answers
1. a
2. c
3. b

CO_2 Respiratory Gas Module Concepts

CO_2 Respiratory Gas Measurement

Description

CO_2 respiratory gas measurements indicate the efficiency of the transfer of oxygen from alveolar air into pulmonary capillary blood and the elimination of carbon dioxide from pulmonary capillary blood and its transfer into alveolar air.

The CO_2 respiratory gas measurements are an indication of the patient's overall respiratory status.

Concepts

Blood Gas concepts important to this section are:

- **Airway Respiration Rate (AWRR)** - The number of inspirations and expirations per minute.
- **End Tidal Volume** - The total volume of air expired in one breath.
- **End Tidal CO_2 ($ETCO_2$)** - The total volume of CO_2 expired in one breath.
- **Inspired Minimum CO_2 ($IMCO_2$)** - The minimum amount of CO_2 inspired in one breath.
- **Instantaneous CO_2** - The CO_2 measurement at any instant.
- **Ventilation** - The movement of air in and out of the lungs by inspiration and expiration.

Measurement Principle

The $ETCO_2$ (End Tidal Carbon Dioxide) measurement for Carbon Dioxide uses a technique based on the absorption of infrared radiation by certain gases.

Infrared light is absorbed by $C0_2$. The amount of absorption varies according to the CO_2 concentration in the gas mixture. By using an infrared detector to measure the absorption, the CO_2 concentration in a gas can be derived.

Measurement Acquisition

CO_2 respiratory gas measurements are evaluated as gas passes through the airway adapter on the patient's intubation system.

Measurement Output

Respiratory CO_2 gas readings are depicted as a real-time CO_2 waveform together with numerics for $ETCO_2$, Airway Respiration Rate (AWRR), and Inspired Minimum Carbon Dioxide ($IMCO_2$).

During calibration, the value for instantaneous CO_2 is also obtained.

Criteria for Proper Measurement

Factors affecting accurate measurements of CO_2 respiratory gas are:

- Proper connection between the measurement module and the patient's respiratory system.
- Temperature of the patient's breath.
- Amount of water vapor in the patient's breath.
- Barometric pressure at the site of measurement acquisition.
- Other gases, most notably N_2O and O_2, in the gas mixture.

Plug-In Modules

Two of Philips' plug-in modules can measure respiratory CO_2: the M1016A CO_2 Module and M1015A Sidestream CO_2 Module. The M1015A module requires the M1016A module to measure sidestream CO_2.

CO_2 Respiratory Gas Measurement Exercises

1. CO_2 respiratory gas measurement is an indication of

   a. overall cardiac status
   b. overall pulmonary status
   c. overall respiratory status

2. CO_2 respiratory gas measurement uses a technique based on:

   a. absorption of infrared radiation
   b. amount of partial pressure exerted
   c. temperature of measurement being collected

3. CO_2 respiratory gas measurement is displayed as a:

   a. numeric value
   b. waveform
   c. percentage amount
   d. a and b

4. What factors can influence the accurate measurement of CO_2 respiratory gas?

   a. temperature of patient's breath
   b. amount of water vapor in patient's breath
   c. a and b

Answers
1. c
2. a
3. d
4. c

CO_2 Respiratory Gas Module (M1016A)

Description

The CO_2 M1016A Module is a carbon dioxide measurement parameter unit. It is designed to be used with adult, pediatric, or neonatal patients in a range of Critical Care environments.

Measurements

The CO_2 M1016A Module produces a real-time CO_2 waveform, together with numeric readings for the End Tidal CO_2, Inspired Minimum CO_2, and Airway Respiration Rate.

During the calibration of the module, the numeric value for instantaneous CO_2 is displayed.

Components

The CO_2 M1016A Module consists of the following major functional components:

Table 2-4 Major CO_2 Module Components

Component	Description
Microprocessor	Controls the overall CO_2 Module functions.
Heater Control	Maintains the temperature of the transducer.
Motor Control	Responsible for rotating the filter wheel at a speed of 40 rotations per minute.
Infrared Detector Signal Transfer	Amplifies signals from the infrared detector and passes it through a dual slope Analog-to-Digital converter.
EEPROM	Calibration constants for the module are stored in the EEPROM during power down. This makes it possible to transport the module together with the sensor without requiring recalibration.
Power Supply	Generates all necessary supplies for the module and the high voltage supply for the infrared detectors. The +60V output from the Computer Module is used to generate the required voltages within the module.

Block Diagram

Figure 2-7 shows the block diagram of the patient's recorded signal flow through the CO_2 M1016A Module.

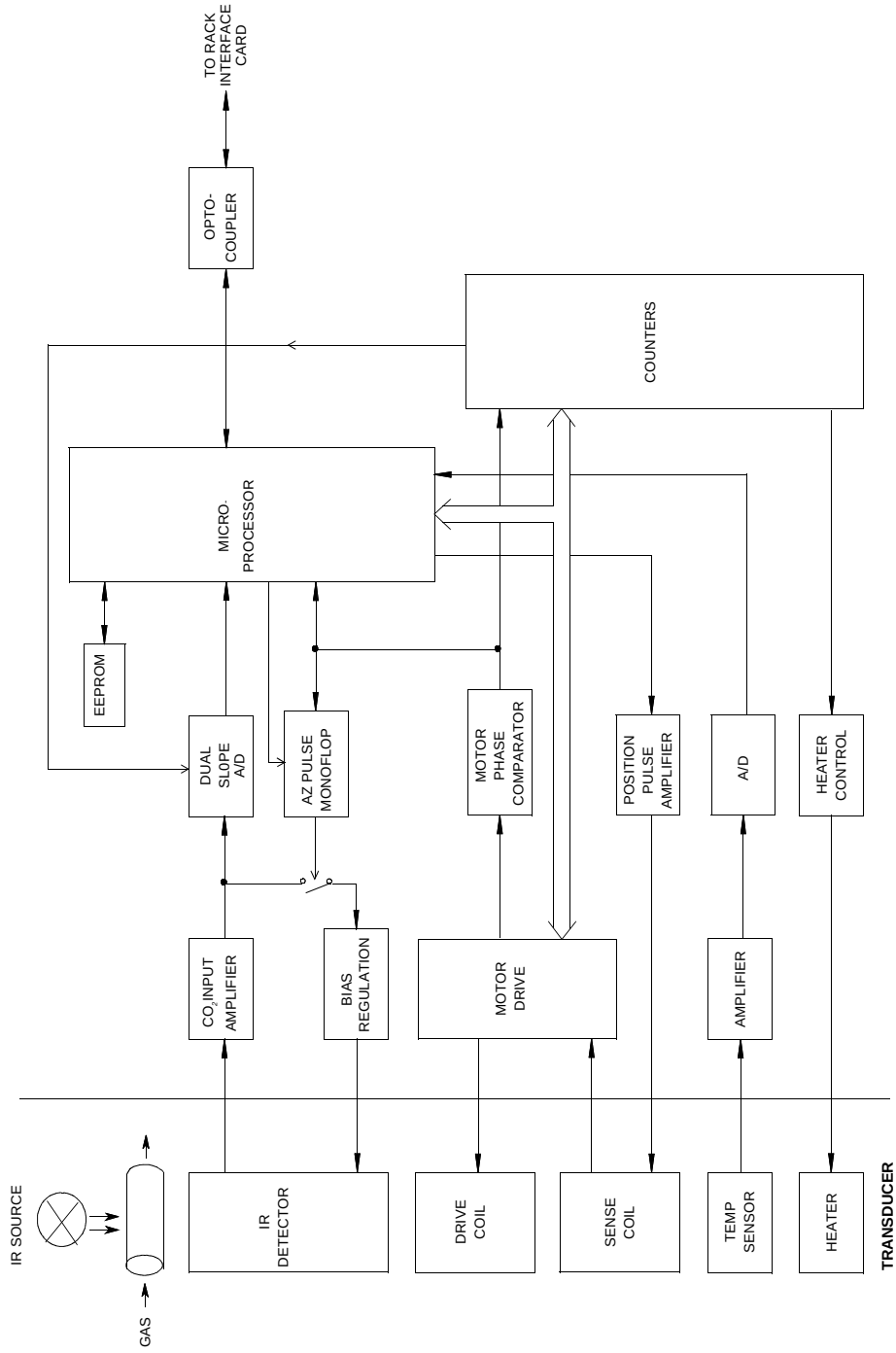


Figure 2-7 M1016A Carbon Dioxide (CO2) Module Block Diagram

Theory of Operation

There are four major sections that the electrical signal must pass through in order that it reach the Monitor interface:

1 The Microprocessor is in overall control of the CO_2 Module functions and also performs the following functions:

- Serial communication, via optocouplers, with the rack interface card in the Computer Module.
- Calculation of the calibration constants.
- Calculation of the raw data of the CO_2 waveform.

Data are passed from the microprocessor to other areas of the module over an internal data bus.

2 The temperature of the transducer is maintained at approximately 33°C to prevent condensation and to negate any discrepancies due to temperature changes. Signals from the temperature sensor in the transducer are amplified and then passed through an Analog-to-Digital converter. The microprocessor then adjusts the output of the motor drive circuitry accordingly.

The microprocessor derives the measurement timing from the motor drive circuitry.

3 Signals from the infrared detector are amplified and passed through a dual slope Analog-to-Digital converter. This converter is controlled by the microprocessor via the counters. The conversion is started at a predefined time and is performed synchronously with the motor rotation.

The “Zero” (GZ), “Sample” (GS), and “Reference” (GR) signals are produced and used as the input values for the CO_2 algorithm.

An auto zero signal (AZ), which is derived from the output of the motor phase comparator, controls the bias regulation of the infrared detector. The AZ signal is enabled or disabled by the microprocessor.

CO_2 M1016A Features

Figure 2-8 shows the user controls and connectors for the CO_2 M1016A Module. Refer to this figure for the User Controls and Connector descriptions.

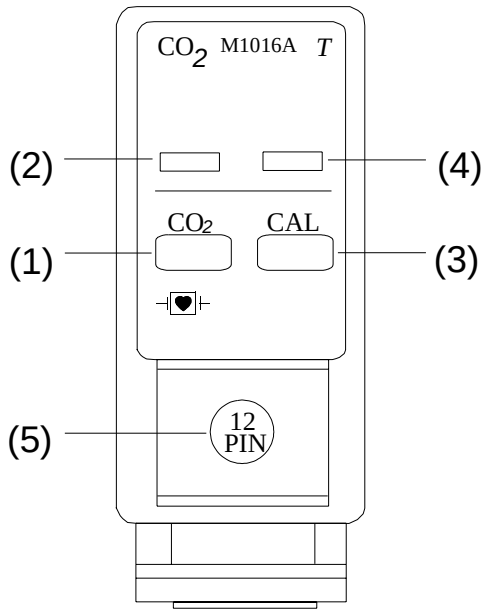


Figure 2-8 $C0_2$ Module Controls and Connectors

User Controls

1 **CO_2 Setup Key**: This is a single-press key, used to enter the CO_2 setup screen.

2 **CO_2 Setup Indicator**: This is a green LED, which will be lit when in the CO_2 setup screen. If, after pressing the setup key, the LED is not lit, the system is busy and the CO_2 setup screen cannot be entered.

3 **CAL key**: This is a single-press key used to enter the CO_2 calibration screen and calibration mode. The calibration screen can be exited by pressing this key a second time, (and calibrations already in progress will not be influenced.)

4 **CAL Indicator**: This is a green LED, which is lit when in the CO_2 calibration mode.

Connectors

5 This is a standard **12-pin connector** for use with a CO_2 Transducer.

Safety

To ensure the safety of the patient, the patient-applied parts are isolated from ground by optical isolators and a transformer. In addition the entire module is encapsulated in plastic.

This module complies with UL544, IED-601-1, CSA C22.2 No. 125. Patient leakage current less than 10µA at 120V/60Hz.

Isolated patient connection to *Class 1* protection, Type *Cardiac Floating (CF)*.

There is also protection against damage from defibrillation and electro surgery.

CO_2 M1016A Module Exercises

1. The CO_2 M1016A Module measures:

   a. Cardiac Output
   b. Carbon Dioxide
   c. Oxygen concentration

2. The CO_2 M1016A Module produces a CO_2 waveform along with all but:

   a. Airway Respiration Rate
   b. Instantaneous CO_2
   c. End Tidal Nitrogen

3. The CO_2 M1016A Module Microprocessor performs which of the following functions?

   a. overall controls the CO_2 Module functions
   b. regulates temperature
   c. regulates the filter wheel at 40 rpms

4. The CO_2 M1016A Module has all but the following user controls:

   a. Partial Pressure alarm key
   b. Setup Key
   c. CAL Indicator

Answers
1. b
2. c
3. a
4. a

Sidestream CO_2 Module (M1015A)

Description

The M1015A Sidestream CO_2 ($SSCO_2$) Module is designed for use with the M1016A CO_2 Module to provide a solution for measuring CO_2 in long-term intubated patients weighing more than 7 kg. Use of the module means that the transducer is not directly placed on the patient's breathing circuit.

Measurements

The M1015A Sidestream CO_2 Module, when used with the CO_2 M1016A Module, produces a real-time CO_2 waveform, together with numeric readings for the End Tidal CO_2, Inspired Minimum CO_2, and Airway Respiration Rate.

During the calibration of the module, the numeric value for instantaneous CO_2 is displayed.

Components

The M1015A $SSCO_2$ Module consists of the following major functional components:

Table 2-5 Major SSCO2 Module Components

Component	Description
Microprocessor	Controls the overall calculations and communication with the CMS function box.
EEPROM	A peripheral to the Microprocessor and where the calibration constants, error codes, and pump driver renting data are stored.
Power Supply	The Floating Power Supply generates the necessary voltage and ensures that there is an electrical separation between the circuitry.
Flow Channel	Controls the offset compensation for the pressure sensors.
Pressure Channel	Uses no offset adjustment.
Pump Driver and Valve	The pump driver and valve are driven by a pulse width modulation signal.
Temperature Sensor	The temperature sensor is used to compensate for the semi conductor and pressure drives.
Multiplexer and A/D Converter	The multiplexor measures the ground signal, 2.5 volt reference, and the 5 volt power supply. All voltages are switched by the multiplexer to the A/D (Analog-to-Digital) converter.

Block Diagram

Figure 2-9 shows the block diagram of the patient's recorded signal flow through the Sidestream CO_2 M1015A Module.

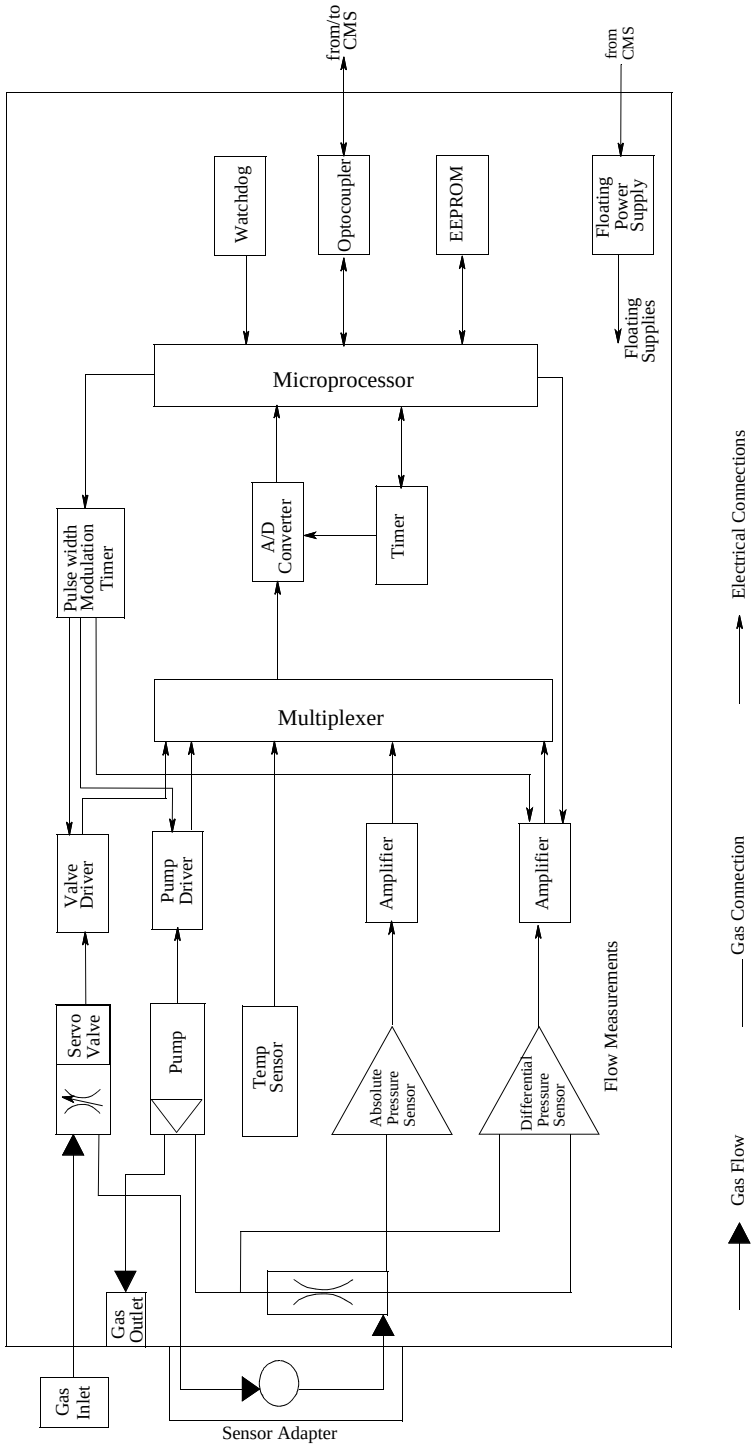


Figure 2-9 Sidestream CO2 Module M1015A Block Diagram

Theory of Operation

The four major sections that the electrical signal must pass through in order to reach the Monitor interface are:

1 The Microprocessor which is in overall control of all calculations and communications with the CMS function box. The Microprocessor performs the following functions:

- Serial communication, via optocouplers, with the rack interface card in the Computer Module.
- Data Acquisition for the differential pressure sensors.
- Control of the pump driver and valve.
- The flow control algorithm.

Data are passed from the microprocessor to other areas of the module over an internal data bus.

2 The flow channel, which consists of a differential pressure sensor and a variable gain amplifier. The flow channel controls the offset compensation for the pressure sensors.

The following two types of sensors may be used:

- Motorola MPX 10
- Sensym SX 01.

The offset compensation is set up so that both types of sensor can be used without changing the software.

3 The pressure channel; no offset adjustment is necessary for the pressure channel.

The following two types of sensor can be used:

- Motorola MPX 100
- Sensym SX 15

4 The pump driver and valve which are driven by a pulse width modulation signal. Both drivers contain a comparator and level switch and a power MOSFET. The pump driver is driven by the positive 7 volt power supply; the valve is driven by the negative 7 volt power supply. Both the pump driver and the valve current can be measured across a resistance (R154, R164). The pump driver contains a safety switch off which is tested cyclically.

M1015A Sidestream CO_2 Module Features

Figure 2-10 shows the user controls and connectors for the M1015A Sidestream CO_2 Module. Refer to this figure for the User Controls and Connector descriptions.

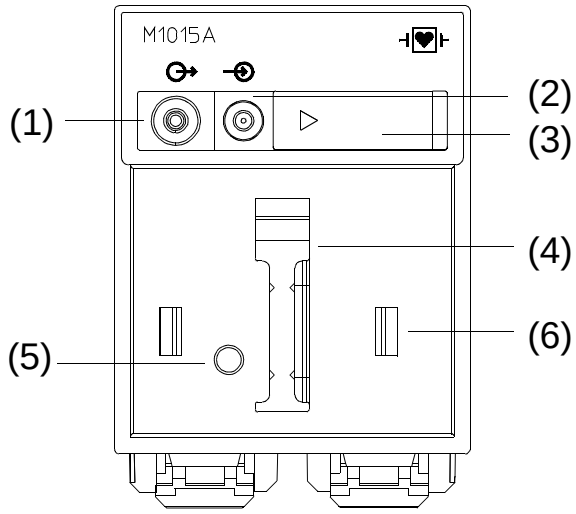


Figure 2-10 Sidestream $C0_2$ Module Controls and Connectors

Connectors

1 **Gas Outlet Connector**: The gas outlet connector lets out the gas after it has been sampled.

2 **Gas inlet Connector**: The gas inlet connector provides the connection for the sample tubing (and bacterial filter) which receives the patient's gas sample.

3 **Slide Cover**: The cover protects the gas inlet connector when the module is not in use.

4 **Sample Cell**: The CO_2 transducer is mounted on the sample cell of the sidestream module. The transducer plug is connected to the M1015A CO_2 Plug-in Module.

5 **Switch**: The switch activates the Sidestream pump when the CO_2 transducer is mounted on the sample cell.

6 **Mounting Clamp**: The mounting clamp holds the CO_2 transducer in place.

Safety

To ensure the safety of the patient, the patient-applied parts are isolated from ground by optical isolators and a transformer. In addition, the entire module is encapsulated in plastic.

This module complies with UL544, IED-601-1, CSA C22.2 No. 125. Patient leakage current is less than 10µA at 120V/60Hz.

Isolated patient connection to *Class 1* protection, Type *Cardiac Floating (CF).*

There is also protection against damage from defibrillation and electro surgery.

M1015A Sidestream Module Exercises

1. What does the M1015A Sidestream CO_2 Module measure?

   a. Invasive Blood Pressure
   b. Cardiac Output
   c. CO_2 Output

2. What component of the M1015A Sidestream CO_2 Module controls the offset compensation for the pressure sensors?

   a. Flow Channel
   b. Pressure Channel
   c. Power Supply

3. The M1015A Sidestream CO_2 Module is used in conjunction with the:

   a. PRESS M1006B Module
   b. CO_2 M1016A Module
   c. PRESS M1006A Module

4. What does the slide cover on the M1015A Sidestream CO_2 Module do?

   a. provides the connection for the sample tubing
   b. activates the sidestream pump
   c. protects the gas inlet connector

Answers
1. c
2. a
3. b
4. c

FIO_2 Module Concepts (CMS only)

FIO_2 Respiratory Measurement

Description

FIO_2 respiratory measurements indicate the percentage of oxygen that is inspired.

The FIO_2 respiratory measurement is an indication of the percentage of oxygen a patient is breathing.

Concepts

Respiratory concepts important to this section are:

- **Fractional Concentration of Oxygen in the inspired air (FIO_2)-** The percent of Oxygen in the inspired air.
- **Total Inspired Gas** - The total volume of gas inspired during one inspiration.
- **Ventilation** - The movement of air in and out of the lungs by means of inspiration and expiration.

Measurement Principle

The measurement method used to determine the fractional oxygen is called the polarographic method.

The transducer comprises an anode and a cathode mounted in an electrolyte and protected by a gas permeable membrane. A polarization voltage is applied between the anode and cathode. Oxygen passing through the membrane is reduced (consumed) at the cathode, resulting in an output current proportional to the amount of O_2 consumed. The fraction of O_2 can then be derived from the measured current.

As the transducer is placed in the inspired pathway of a ventilated patient, the measurement provides a value for the O_2 concentration, expressed as a fraction of the inspired air.

The temperature dependency of the polarographic method is compensated by an internal thermistor in the sensor.

Normal values for $FI0_2$ are: ambient air, 21% or 0.21. Depending on the patient's condition, the percentage of Oxygen sent to the patient may vary from this amount.

Measurement Acquisition

The FIO_2 respiratory measurement is collected by way of an airway adapter on the patient's intubation system.

Measurement Output

The respiratory FIO_2 reading is depicted as a numeric value expressed as a fraction of the total inspired gas.

Criteria for Proper Measurement

Factors affecting accurate measurements of FIO_2 are:

- Proper connection between the measurement module and the patient's ventilation system.

Plug-In Modules

The M1017A FIO_2 Plug-in Module measures fractional inspired oxygen.

Automatic compensation for O_2 interference when measuring respiratory CO_2 is achieved when the FIO_2 Module is in use.

FIO_2 Respiratory Measurement Exercises

1. FIO_2 respiratory measurement is an indication of

    a. the percent of inspired oxygen
    b. the percent of expired oxygen
    c. the percent of inspired CO_2

2. FIO_2 respiratory measurement uses a technique based on:

    a. the polographic method
    b. amount of partial pressure exerted
    c. absorption of infrared radiation

3. FIO_2 respiratory measurement is displayed as a:

    a. blinking light
    b. waveform
    c. numeric value

4. What factors can influence the accurate measurement of FIO_2?

    a. temperature of patient's breath
    b. proper connection between the module and the patient's ventilation system
    c. amount of water vapor in patient's breath

Answers

1. a

2. a

3. c

4. b

FIO_2 Module (M1017A)

Description

The FIO_2 M1017A Module is an inspired oxygen measurement parameter unit. It is designed to be used with adult, pediatric, or neonatal patients in a range of Critical Care environments.

Measurements

The FIO_2 M1017A Module produces a numeric display for the fractional inspired oxygen.

Components

The FIO_2 M1017A Module consists of the following major functional components:

Table 2-6 Major FiO2 Module Components

Component	Description
Polarization Circuitry	The polarization voltage is derived from the power supply of the module when the power is ON. When the power is OFF, this voltage is derived from a built-in battery (for a minimum of four days).
Low Battery and Test Signal	The voltage of the built-in polarization battery is sensed so that a failed battery can be detected. For testing purposes, a test signal is generated in the current-to-voltage converter circuitry. The numeric 0.21 FIO_2 indicates that the module is working correctly. This battery is rechargeable.

Block Diagram

Figure 2-11 shows the block diagram of the recorded patient signal flow through the FIO_2 M1017A Module.

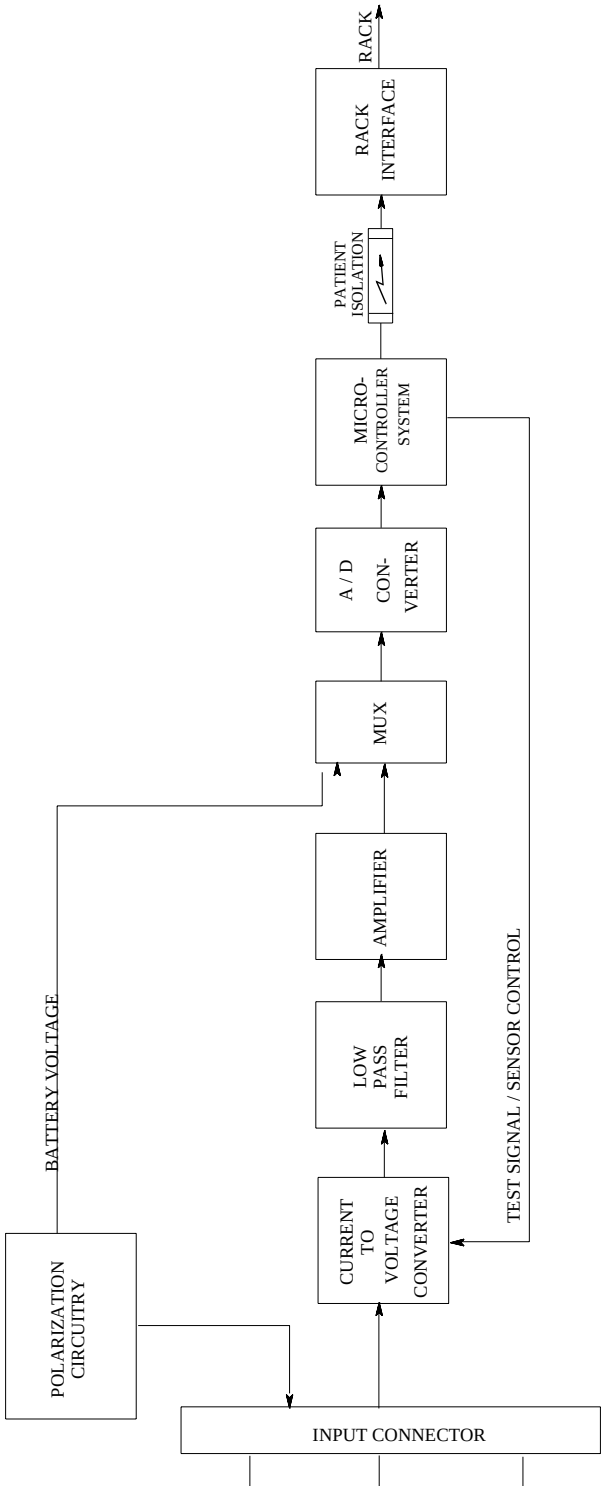


Figure 2-11 M1017A FIO_2 Module Block Diagram

Theory of Operation

The major actions on the electrical signal before it reaches the Monitor interface are as follows:

The FIO_2 signal is generated when the current produced by the electro-reduction of oxygen at the cathode is converted to a voltage. This voltage is then input to a low pass filter and the filtered signal is amplified before being passed through the multiplexer to the Analog-to-Digital converter.

FIO_2 M1017A Features

Figure 2-12 shows the user controls and connectors for the FIO_2 M1017A Module. Refer to this figure for the User Controls and Connector descriptions.

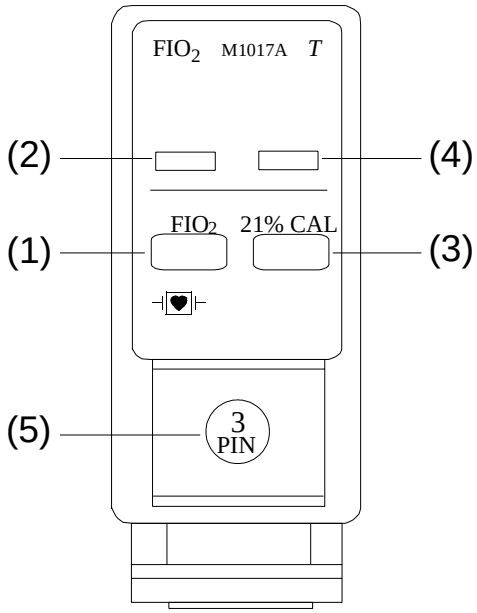


Figure 2-12 FIO_2 Module Controls and Connectors

User Controls

1 **FIO_2 Setup Key**: This is a single-press key, used to enter the FIO_2 setup screen.

2 **FIO_2 Setup Indicator**: This is a green LED, which will be lit when in the FIO_2 setup screen. If, after pressing the setup key, the LED is not lit, the system is busy and the FIO_2 setup screen cannot be entered. The setup key must be pressed again.

3 **21% CAL Key**: This is a single-press key used to initiate the FIO_2 21% calibration procedure. The key must be pressed for at least one second to start calibration. The calibration task window is not displayed when the calibration is initiated using this key.

4 **CAL Indicator**: This is a green LED, which is lit when in the FIO_2 calibration mode.

Connectors

5 This is a standard **3-pin connector** for use with a FIO_2 Transducer.

Safety To ensure the safety of the patient, the patient-applied parts are isolated from ground by optical isolators and a transformer. In addition, the entire module is encapsulated in plastic.

This module complies with UL544, IEC-601-1, CSA C22.2 No. 125. Patient leakage current is less than 10μA at 120V/60Hz.

Isolated patient connection to *Class 1* protection, Type *Cardiac Floating (CF)*.

There is also protection against damage from defibrillation and electrosurgery.

FIO_2 M1017A Module Exercises

1. The FIO_2 M1017A Module measures:

   a. Fractional inspired Oxygen
   b. Carbon Dioxide
   c. Oxygen concentration

2. The FIO_2 M1017A Module produces a:

   a. Numeric display
   b. Waveform
   c. Blinking light

3. The FIO_2 M1017A Module low battery and test signal performs which of the following functions?

   a. Controls the FIO_2 Module overall functions
   b. Detects a failed battery
   c. regulates temperature

4. The FIO_2 M1017A Module has all but the following user controls:

   a. CAL Indicator
   b. Setup Key
   c. Partial Pressure alarm key

Answers

1. a
2. a
3. b
4. c

Transcutaneous Gas ($tcpO_2$/$tcpCO_2$) Module Concepts

tcpO2/tcpCO2 Measurement

Description

Transcutaneous gas measurements indicate the partial pressures of oxygen and carbon dioxide in a patient's blood system as measured through the skin.

The transcutaneous gas measurement is an indication of the amount of oxygen a patient is getting and how well the heart is working.

Concepts

Transcutaneous gas concepts important to this section are:

- **Transcutaneous -** Through the skin.

Measurement Principle

Different measurement principles exist for the $tcpO_2$ and $tcpCO_2$ parameters. One, or both, can be implemented with the transducer, and, when both are implemented, they are implemented by a "combined" transducer. Both measurement principles require the use of a topical electrolyte.

For $tcpO_2$ measurement, a silver/platinum Clark electrode is used. When a constant voltage is applied to the electrode, it produces a very small electrical current proportional to the $tcpO_2$ pressure. This current is converted into a voltage and amplified in the transducer plug.

For $tcpCO_2$ measurement, a solid state pH glass electrode is used. This electrode produces a voltage related to the electrolyte's pH value. The pH value is dependent on the CO_2 pressure. The electrode voltage and the CO_2 pressure are logarithmically related. The electrical signal from the electrode is amplified within the transducer plug.

The O_2 and CO_2 in the patient's blood diffuses through the skin and then passes through the sensor's membrane into the electrolyte. The O_2 molecules are reduced on the platinum electrode and generate a small current proportional to the O_2 pressure. The CO_2 molecules alter the pH of the electrolyte until an equilibrium is obtained. The change in pH is converted into a voltage proportional to the CO_2.

To establish that the voltage or current levels correspond to the CO_2 or O_2 partial pressures, the transducer is calibrated. The transducer is exposed to a calibration gas of defined values for pCO_2 and pO_2. The transducers require calibration due to the fact that CO_2 transducers have an unknown offset and O_2 transducers have an unknown sensitivity. Any transducer not calibrated regularly will misread, and the measurement is inhibited until a calibration is performed.

The transducer is heated to improve the diffusion of CO_2 and O_2 from the patient's skin and to maintain an absolute constant temperature. Any change in the transducer's temperature changes its characteristics, so the user must make a new calibration if and after the set temperature has been changed.

Measurement Acquisition

The transcutaneous gas measurement is noninvasive using a transducer attached to the patient's skin.

Measurement Output

The transcutaneous gas readings are depicted as numerics on the display and as graphical and numeric trend information for the partial O_2 and CO_2 measurements.

Criteria for Proper Measurement

Factors affecting accurate measurements of transcutaneous gas are:

- proper connection between the measurement module and the patient's transducer.
- any change in the transducer's temperature, which changes its characteristics and may affect accurate measurement

Plug-In Modules

The M1018A $tcpO_2$/$tcpCO_2$ Plug-in Module, in conjunction with a transducer, measures transcutaneous O_2 and CO_2 carbon dioxide partial pressures.

tcpO2/tcpCO2 Measurement Exercises

1. $tcpO_2/tcpCO_2$ measurement is an indication of:

   a. partial pressure of oxygen
   b. partial pressure of carbon dioxide
   c. both a and b

2. $tcpO_2/tcpCO_2$ measurement requires the use of:

   a. an electrode
   b. an invasive catheter
   c. a respiration transducer

3. $tcpO_2/tcpCO_2$ measurement is displayed as a:

   a. numeric values and as graphical and numeric trend information
   b. waveform
   c. fraction

4. What factors can influence the accurate measurement of $tcpO_2/tcpCO_2$?

   a. temperature of patient's blood
   b. amount of water vapor in patient's blood
   c. any change in the transducer's temperature

Answers
1. c
2. a
3. a
4. c

tcpO2/tcpCO2 Module (M1018A)

Description

The Transcutaneous Gas ($tcpO_2$/$tcpCO_2$) Module M1018A is a measurement parameter unit measuring transcutaneous oxygen and carbon dioxide partial pressures.

Measurements

The $tcpO_2$/$tcpCO_2$ M1018A Module produces graphical and numeric trend information for the partial O_2 and partial CO_2 pressure measurements.

Calibration Algorithm

The $tcpO_2$/$tcpCO_2$ M1018A Module uses a calibration algorithm consisting of four check procedures:

Warm-up Check - The transducer temperature is tested in this check. Under normal conditions, the temperature will be heated to the preset temperature within 2 minutes. The test allows a maximum of 3 minutes for the transducer to warm-up to the preset temperature.

Range Check - The $tcpO_2$ and $tcpCO_2$ signals are checked in this test. If they are not within the acceptable range in 1 minute, the monitor rejects the calibration and displays the calibration failed message.

Stability Check - The stability of the electrode is checked in this test. The stability check is activated on successful completion of the range check. The calibration is completed when the transducer signal fluctuation is less than 1% per minute. A maximum of 15 minutes is allowed for this check.

$tcpCO_2$ Post Calibration Check - This check ensures that the CO_2 element of the transducer responds to the change in the CO_2 level that occurs when removing the transducer from the calibration chamber.

If the signal does not change within 10 seconds after removing the transducer from the chamber, the message **$tcpO_2$/$tcpCO_2$, transducer**, or **Cal Unit Malf** will be displayed.

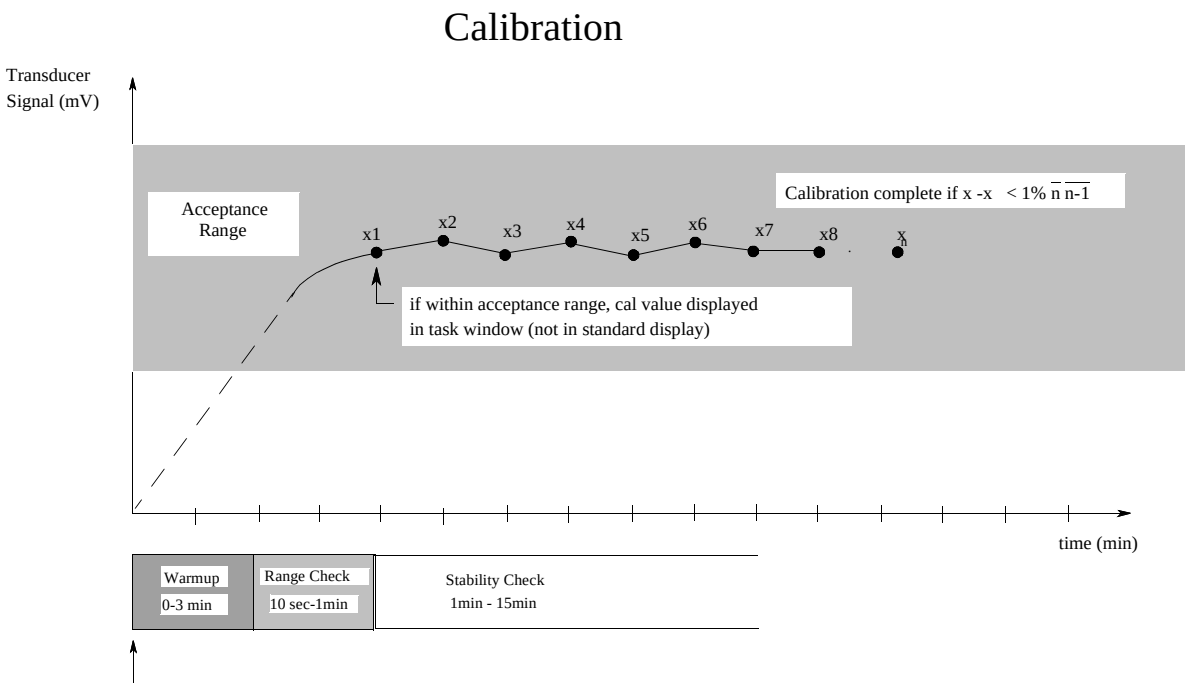


Figure 2-13 Graphic Representation of the Calibration Algorithm

Components

The $tcpO_2$/$tcpCO_2$ M1018A Module consists of the following major functional components:

Table 2-7 Major tcpO2/tcpCO2 Module Components

Component	Description
Microprocessor	Controls overall functions of the $tcpO_2$/$tcpCO_2$ Module.
Heater	Heats the transducer to improve diffusion of gases.
Polarization Supply	Produces a polarization voltage of 680 mV for the O_2 sensor via the O_2 amplifier. The polarization voltage is monitored by the microprocessor.
Relay	The relay replaces raw signals from the transducer with test signals designed to test the two separate analog signal paths for O_2 and CO_2.
Identifier	The identifier circuitry identifies which transducer is being used: a $tcpO_2$ transducer, a $tcpCO_2$ transducer, or the Philips combined transducer.
Multiplexer	The multiplexer collects the analog signals, interleaves them, and feeds them to the dual-slope analog-to-digital converter.
EEPROM	The calibration constants for the module are stored in the EEPROM along with other data.
Calibration Chamber	The calibration chamber determines whether the transducer has been positioned in the calibration chamber on the module, or is actually being used on a patient.
Power Supply	All necessary supplies for the $tcpO_2$/$tcpCO_2$ Module are generated in an internal power supply. The +60V output from the Computer Module is used to generate the required voltages within the module.

Block Diagram

Figure 2-14 shows the block diagram of the recorded patient signal flow through the $tcpO_2$/$tcpCO_2$ M1018A Module.

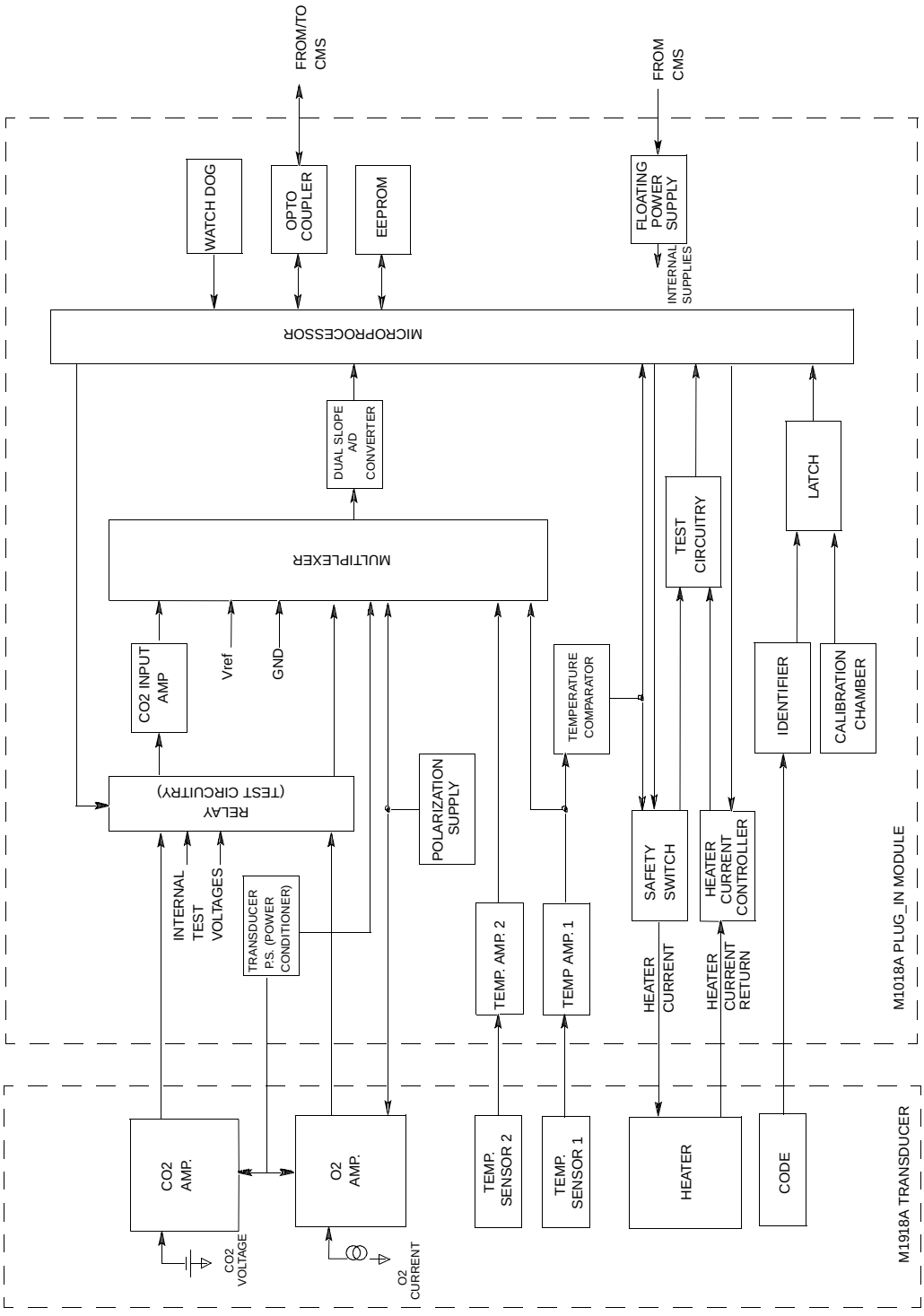


Figure 2-14 M1018A Transcutaneous Gas ($tcpO_2$/$tcpCO_2$) Module Block Diagram

Theory of Operation

The major actions that the electrical signal must pass through in order to reach the Monitor interface:

1 The microprocessor which controls the overall functions of the module and also controls transducers, safety tasks, and all application software (e.g. calibration, value calculation). Additionally, the microprocessor performs the following functions:

- serial communication, via optocouplers, with the rack interface card in the Computer Module
- calculation of the calibration constants
- calculation of the $tcpO_2$/$tcpCO_2$ numerics
- transducer temperature control

2 The heater control, which heats the transducer to improve the diffusion of gases from the blood to the skin surface by maintaining constant absolute temperature. The transducer temperature is measured by two independent sensors simultaneously.

Power is supplied to the heater by the heater current controller, which in turn is controlled by the microprocessor; the microprocessor derives this control signal from the measured temperature.

The heater can be switched off using the safety switch whenever any abnormal conditions occur; this safety switch is controlled by both the microprocessor and the temperature comparator. Test circuitry provides both the switch and the current controller with a continuous self-test.

3 The Relay, which routes the CO_2 signal to the CO_2 input amplifier, which, in turn, amplifies the signal and passes it on to the multiplexer. The relay reroutes the O_2 signal directly to the multiplexer.

4 The Calibration Chamber. The calibration chamber circuitry determines whether the transducer has been positioned in the calibration chamber on the module, or is actually being used on a patient. A standby mode is initiated when the transducer has been placed in the chamber for more than 30 minutes; for example, the heater is switched off to minimize transducer dehydration, therefore extending the time between remembraning.

The $tcpO_2$/$tcpCO_2$ limit alarms are suspended automatically when a transducer is inserted into the calibration chamber.

$tcpO_2/tcpCO_2$ M1018A Features

Figure 2-15 shows the user controls and connectors for the $tcpO_2/tcpCO_2$ M1018A Module. Refer to this figure for the User Controls and Connector descriptions.

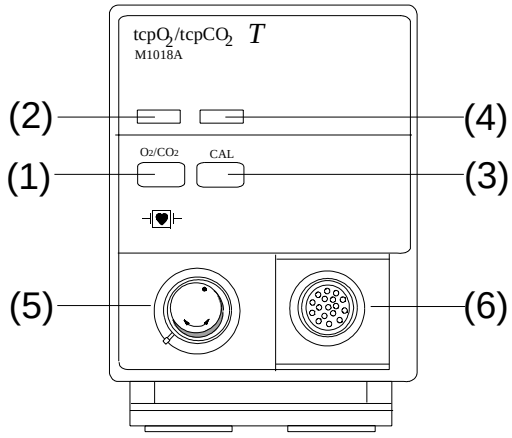


Figure 2-15 tcpO2/tcpCO2 Module Controls and Connectors

User Controls

1 **O_2/CO_2 Setup Key:** This is a single press-key, used to enter the $tcpO_2/tcpCO_2$ setup screen.

2 **O_2/CO_2 Setup Indicator**: This is a green LED, which will be lit when in the $tcpO_2/tcpCO_2$ Setup Screen.

3 **CAL key:** This is used to start the calibration process directly when in the Task Window.

4 **CAL Indicator:** This LED will be lit when the CAL key is pressed and during calibration.

Connectors

5 **Calibration chamber** with gas inlet.

6 A **20-pin connector** for use with the $tcpO_2/tcpCO_2$ transducer.

Safety

To ensure the safety of the patient, the patient-applied parts are isolated from ground by optical isolators and a transformer. In addition, the entire module is encapsulated in plastic.

This module complies with UL544, IED-601-1, CSA C22.2 No. 125. Patient leakage current is less than 10µA at 120V/60Hz.

Isolated patient connection to *Class 1* protection, Type *Cardiac Floating (CF)*.

There is also protection against damage from defibrillation and electro surgery.

$tcpO_2/tcpCO_2$ M1018A Module Exercises

1. The $tcpO_2/tcpCO_2$ M1018A Module measures:

   a. Partial pressures of oxygen and carbon dioxide
   b. Mixed Venous Oxygen
   c. Oxygen concentration

2. The $tcpO_2/tcpCO_2$ M1018A Module produces a:

   a. Graphical and numeric trend information
   b. Waveform
   c. Numeric Value

3. The $tcpO_2/tcpCO_2$ M1018A Module Relay performs which of the following functions?

   a. Manages light intensity
   b. Routes the O_2 and CO_2 signals to the multiplexer

4. The $tcpO_2/tcpCO_2$ M1018A Module uses which kind of connector?

   a. Standard 12-pin
   b. Standard 3-pin
   c. 20-pin

Answers

1. a
2. a
3. b
4. c

SvO_2 Blood Gas Module Concepts (CMS only)

SvO_2 Blood Gas Measurement

Description

SvO_2 blood gas measurements indicate the amount of mixed venous oxygen saturation in a patient.

The SvO_2 blood gas measurement is an indication of the amount of oxygen a patient is consuming and how well the heart is working.

Concepts

Blood gas concepts important to this section are:

- **Oxygen Saturation**- The amount of dissolved oxygen in a blood sample.

Measurement Principle

The SvO_2 measurement is based on the progressive change in color of the blood from scarlet to purple as oxygen saturation decreases.

Light of different selected wavelengths illuminates the blood. The light is absorbed, refracted, and reflected by the blood. The amount of light detected depends on the blood's color and, from this information, the venous oxygen saturation is obtained.

Measurement Acquisition

The mixed venous oxygen saturation measurement is continuous and invasive, using a fiber optic catheter. The catheter is usually combined with the C.O. pulmonary artery catheter (Swan-Ganz) and routed via the right side of the heart into the pulmonary artery.

Measurement Output

The SvO_2 reading is depicted as a numeric value. A trend and a displayed light intensity are displayed in the Task Window.

Criteria for Proper Measurement

Factors affecting accurate measurements of SvO_2 are:

- Proper connection between the measurement module and the patient's blood catheter
- Positioning of the catheter.

Plug-In Modules

The M1021A SvO_2 Plug-in Module measures mixed venous oxygen saturation.

SvO_2 Blood Gas Measurement Exercises

1.SvO_2 blood measurement is an indication of:

a. amount of CO_2 in the blood
b. amount of mixed venous oxygen saturation
c. amount of Fractional Oxygen in the blood

2. SvO_2 blood measurement uses a technique based on:

a. the polographic method
b. progressive change in blood color
c. amount of partial pressure exerted

3. SvO_2 blood measurement is displayed as a:

a. numeric value
b. waveform
c. fraction

4.What factors can influence the accurate measurement of SvO_2?

a. temperature of patient's blood
b. amount of water vapor in patient's blood
c. proper connection between the measurement module and the patient

Answers

1. b
2. b
3. a
4. c

SvO_2 Module (M1021A)

Description

The SvO_2 M1021A Module is a mixed venous oxygen saturation measurement parameter unit. It is designed to be used with adult, pediatric, or neonatal patients in a range of Critical Care environments.

Measurements

The SvO_2 M1021A Module produces the numerics, trends, and a displayed light intensity for the mixed oxygen saturation value.

Components

The SvO_2 M1021A Module consists of the following major functional components:

Table 2-8 Major SvO_2 Module Components

Component	Description
Analog-to-Digital Converter	Converts the signal from the Optical Module.
Data Flow Manager (Analog CPU)	Receives and processes signal from the A/D converter and checks the heater, LED current, and fuse functions.
Data Processor (Algorithm CPU)	Receives the first-level averaged data and calculates the SvO_2 measurement.
Data Communication Circuitry	Processes the signal and sends it to the rack interface.

Block Diagram

Figure 2-16 shows the block diagram of the recorded patient signal flow through the SvO_2 M1021A Module.

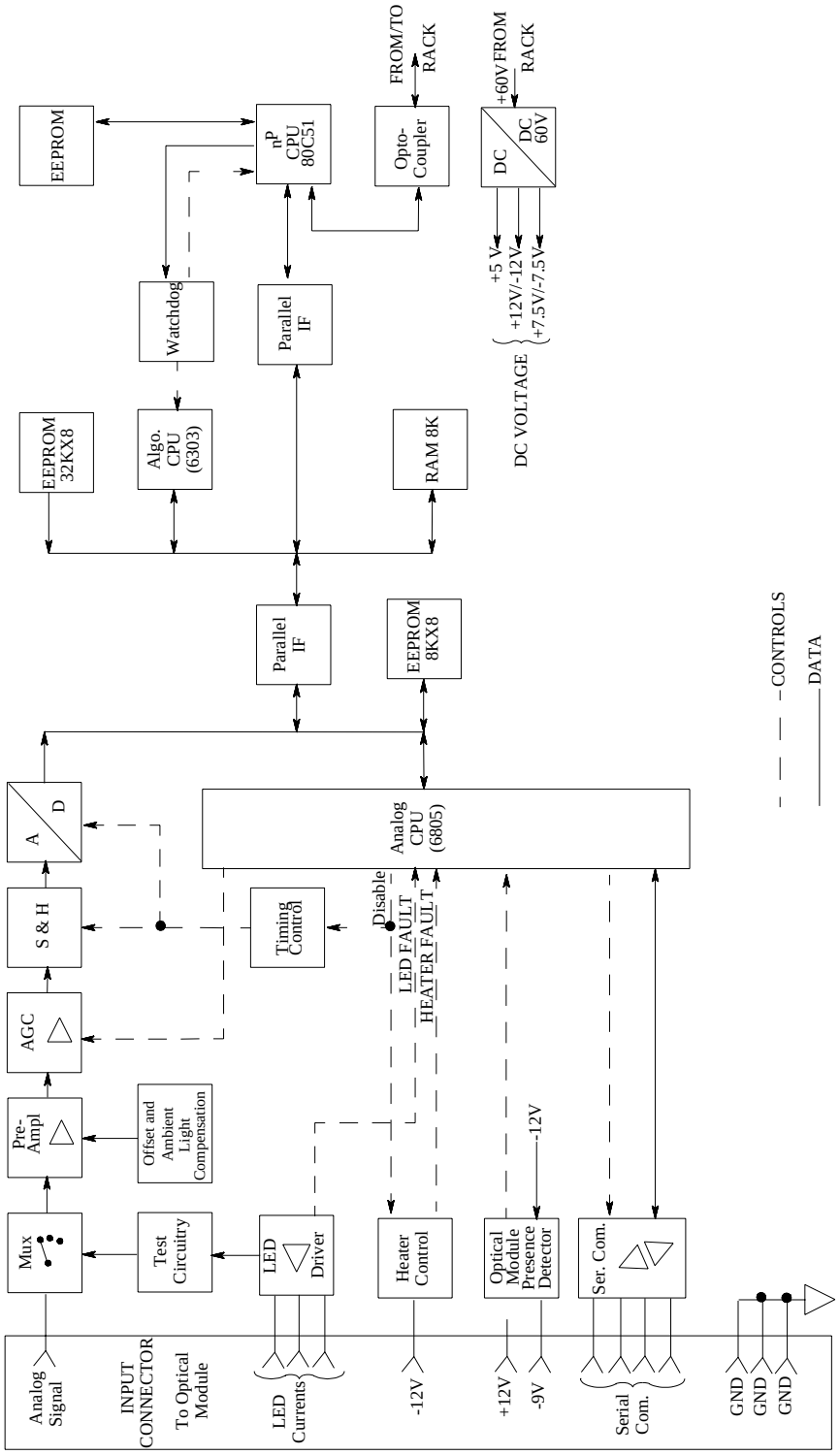


Figure 2-16 SvO_2 M1021A Module Block Diagram

Theory of Operation

The major actions that the electrical signal must pass through in order to reach the Monitor interface:

1 The signal is obtained by the Abbott catheter and processed by the Abbott Optical Module (50131-04) used with the M1021A SvO_2 Module.

There are three light emitting diodes in the Optical Module. Each diode emits a light with a specific wavelength at a frequency of 244 pulses per second through a single fiber-optic filament within the catheter. The light illuminates the blood at the fiber tip. The blood absorbs, refracts, and reflects the light. The reflected light is collected by the aperture of a second fiber-optic filament within the catheter and returned to the photodetector in the Optical Module. The photodetector converts the light sample into an analog signal. This signal is then amplified and transmitted to the SvO_2 Module by the signal amplifier.

An EEPROM in the Optical Module stores:

- up to 15 minutes of parameter related physiological data. This stored data can be recalled and displayed.
- all calibration constants

2 The signal gets processed in the SvO_2 Module by going through four distinct stages:

- Signal Conversion (analog-to-digital)
- Data flow manager (Analog CPU)
- Data Processing (Algorithm CPU)
- Data communication processing (Module - rack interface)

3 Signal Conversion - the analog signal that represents the three reflected wavelengths from the Optical Module is amplified by a variable gain stage and then converted into a digital signal by the analog-to-digital (A/D) converter. This digital signal is passed via the Data Flow Manager (Analog CPU 6805) for the Data Processor (Algorithm CPU 6303).

4 Data Flow Manager (Analog CPU) - The primary functions of the Analog CPU (6805) are as follows:

- collection and first level averaging of the data received from the A/D Converter
- gain Control of the analog processing channel
- low-level EEPROM memory for driver functions
- performs self-test which checks the heater, LED current, and fuse functions of the module

5 Data Processor (Algorithm CPU) -the Algorithm CPU (6303) receives the first-level averaged data from the Analog CPU and calculates the SvO_2 measurement value. The oxygen saturation is derived based on the relative signal intensity ratio of each reflected wavelength. The resulting value is passed to the data communication processing circuitry of the module.

The Algorithm CPU is also responsible for managing light intensity data and generating light intensity alarms.

6 Data Communication Processing - The parallel signal (SvO_2 value) from the Algorithm CPU is converted to a serial signal. This signal is passed via the data communication processing circuitry to the rack interface of the CMS.

The EEPROM stores the settings transfer data which it receives from the CMS for module transport purposes.

SvO_2 M1021A Features

Figure 2-17 shows the user controls and connectors for the SvO_2 M1021A Module. Refer to this figure for the User Controls and Connector descriptions.

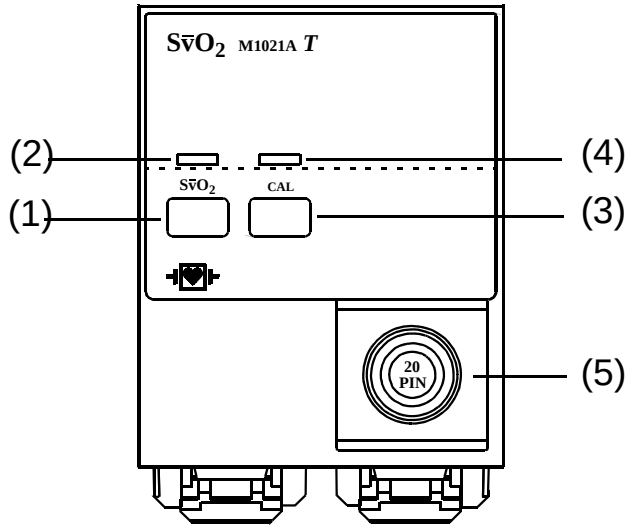


Figure 2-17 SvO_2 Module Controls and Connectors

User Controls

1 **Setup Key**: This is a single-press key, used to enter the SvO_2 setup screen.

2 **Setup Indicator**: This is a green LED, which will be lit when in the SvO_2 setup screen. If, after pressing the setup, key the LED is not lit, the system is busy and the SvO_2 setup screen cannot be entered. The setup key must be pressed again.

3 **CAL key**: This is a single-press key used to enter the module's calibration screen and initiate SvO_2 calibration procedures.

4 **CAL Indicator**: This is a green LED, which is lit during an SvO_2 calibration procedure.

Connectors This is a customized **20-pin connector** for use with the Abbott Optical Module.

Safety To ensure the safety of the patient, the patient-applied parts are isolated from ground by optical isolators and a transformer. In addition, the entire module is encapsulated in plastic.

This module complies with UL544, IEC-601-1, CSA C22.2 No. 125. Patient leakage current is less than 10µA at 120V/60Hz.

Isolated patient connection to *Class 1* protection, Type *Cardiac Floating (CF)*.

There is also protection against damage from defibrillation and electrosurgery.

SvO_2 M1021A Module Exercises

1. The SvO_2 M1021A Module measures:

   a. Carbon Dioxide
   b. Mixed Venous Oxygen
   c. Oxygen concentration

2. The SvO_2 M1021A Module produces a:

   a. Fraction Value
   b. Waveform
   c. Numeric Value

3. The SvO_2 M1021A Module Data Flow Manager performs all but which of the following functions?

   a. Manages light intensity
   b. Performs self-tests to check the heater
   c. Receives data from the A/D Converter

4. The SvO_2 M1021A Module uses which kind of connector?

   a. Standard 12-pin
   b. Customized 20-pin
   c. Standard 3-pin

Answers

1. b
2. c
3. a
4. b

Blood Analysis Module Concepts

Blood Analysis Measurement

Description

Depending on cartridge configuration, the concentration of a combination of electrolytes, blood gases and other analytes in whole blood is determined. A detailed description of each analyte and its clinical relevance can be found in the i-STAT System Manual in the Cartridge and Test Information section.

Concepts

Blood analysis concepts important to this section are:

- Plasma - the fluid component of blood; a solution of proteins (approx. 7%), salt (approx. 0.9%) and glucose (approx. 0.1%) in water.
- Whole blood - blood that has not been separated into its components such as leukocytes, red blood cells, plasma or platelets.
- Electrolyte - a substance that yields ions in solution so that its solutions conduct electrolytes.

Measurement Principle

There are three types of electrodes incorporated into the cartridges:

- Potentiometric
- Amperometric
- Conductometric

These are all thin film electrodes microfabricated onto silicon chips. Sensing functionality is imparted to each electrode by a number of chemically sensitive films coated over the active region of the electrodes.

Potentiometric Measurements

Potentiometry is the measurement of the difference in potential that exists between an indicator electrode and a reference electrode. Ion-selective electrodes (ISE) are examples of potentiometric systems. The indicator electrode is designed to be sensitive to a particular ion in a solution. In cases where other ions are sensed by the system, selectivity coefficients can be used to correct for this interference. An enzyme can be added to an ISE to produce ions from other analytes.

The Nernst Equation

The Nernst equation relates the measured potential to the activity of the ion being measured.

$E=E^\circ + RT/nF \ln a$

Where E is the potential, E° is a constant dependent on the electrode/sensor system, R is the gas constant, T is the absolute temperature, F is Faraday's constant and n is the valance or charge, either positive or negative, for the ion being measured, and a is the activity of that ion.

The Nernst equation can be rewritten as:

$E=E° + S \log a$

Where S replaces the constant terms which define the slope of the sensor. The slope is the change in millivolts per tenfold change in activity. For a positively charged monovalent ion, the theoretical slope would be 59.16mV at 25°C.

When the potential for a calibrant, with known activity, and a sample are measured, the activity of the sample can be calculated from

$E_{sample} - E_{calibrant} = S \log (a_{sample}/a_{calibrant})$

Complex solutions such as blood, deviate slightly from Nernstian behaviour due to interfering ions and matrix effects which result in junction potentials. By including selectivity coefficients in the Nernst equation (Nikolsky equation) these effects can be minimized. By characterizing the reference electrode in different solutions, effects of matrix on the reference junction potential can also be minimized.

Activity versus Concentration

Ion-selective electrodes measure activity rather than concentration. Activity (a) is related to concentration (c) through the activity coefficient (γ): $a = \gamma c$.

While ion activities, which reflect free rather than total ion concentrations, are physiologically important, activity values are converted to conventional concentration units so that values obtained by direct ISE can be compared to values obtained from indirect (diluted) ISE methods which have activity coefficients close to unity or one, and to flame photometric, atomic absorption and titration methods, all of which measure total ion concentration.

Amperometric Measurement

In amperometric measurements, a potential is applied to the measuring electrode while current generated by the oxidation or reduction reactions in the test system is measured. The current generated is directly proportional to the concentration of the analyte. Concentration can be calculated using:

- the known value of the analyte in the calibrant
- the measured current generated by the analyte in the calibrant
- the measured current generated by the analyte in the test solution.

Conductometric Measurement

The conductometric measurement involves the application of an alternating current to the test solution. In aqueous solutions, conductivity is dependent upon the concentration of electrolytes, with an increase in the electrolytes causing an increase in conductivity. In whole blood, the plasma conducts electricity while the cellular

constituents, red and white blood cells and platelets, do not. As the number of cells per unit volume of plasma increases, the conductivity of the sample decreases. Cell concentration can be calculated using:

- the known electrolyte concentration of the calibrant
- the measured electrolyte concentration of the sample
- the measured conductivity of the calibrant, and
- the measured conductivity of the sample.

Measurement Acquisition

Measurements are performed on undiluted specimens of whole blood. Undiluted methods are also called direct methods while methods requiring dilution of the sample are called indirect methods.

It is known that direct methods read up to 7% higher than indirect methods for electrolytes because of the excluded volume occupied by plasma protein and lipids. Typically, however, the elevation of results is less than the full 7% because some of the analyte is bound to protein and other ions and is not assayed by direct methods. Indirect methods measure the total molar concentration of analyte per unit volume of plasma. Direct methods measure the total molar activity of analyte (apparent or free ion activity) per unit volume of plasma water. It is understood that the direct method result is the clinically significant result for electrolytes, and when there is disagreement between methods, such as when the patient has abnormal total protein or lipid levels, it is due to an interference on the indirect method.

At normal levels of protein and lipids the systematic offset between methods is often corrected for in commercial direct measuring instruments so that the normal ranges for all instruments are in agreement. Sensor outputs have been set so that normal ranges are in agreement with indirect reference methods at normal levels of total protein and lipids.

Direct measurement of hematocrit by the conductometric technique gives a result related to the non-conducting excluded volume fraction of the sample fluid. Red blood cell volume is the predominant component of the non-conducting volume, but proteins, lipids and white blood cells also contribute. Elevated hematocrit readings are expected at abnormally elevated levels of these components. Decreased hematocrit readings are expected at abnormally low levels of protein, such as found in samples taken from patients on perfusion pumps.

Osmotic imbalance causes a discrepancy between direct (conductometric, spun) and indirect (Coulter) measurements, because of variation in mean cell volume *in vivo*.

Measurement Output

The analysis results are depicted as a numerics listing with the cartridge type and sample type shown at the top. The measured parameter results are displayed together with the corresponding units. Calculated results are marked with a’ for example ’HCO_3. Temperature adjusted values are marked with an &, for example &PCO_2.

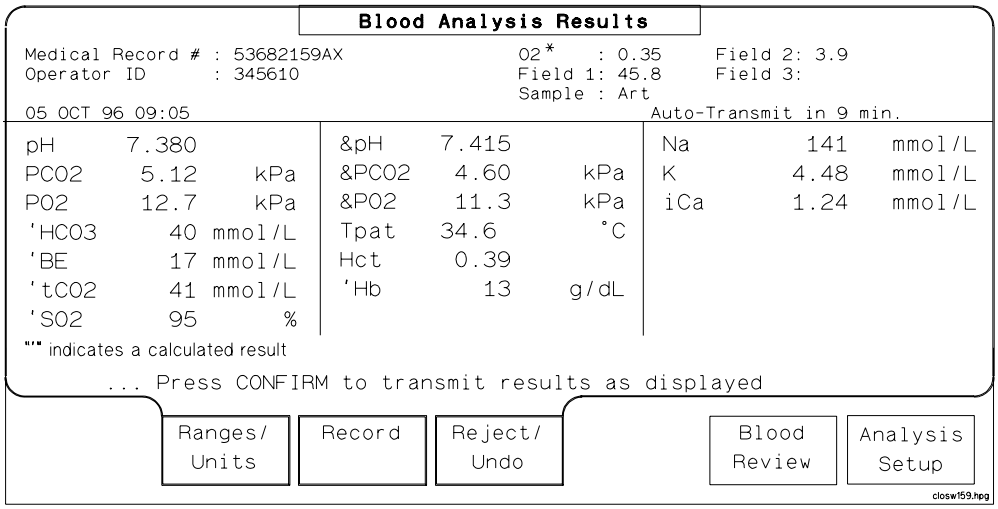


Figure 2-18 Blood Analysis Results Window

Negative Factors Affecting Proper Measurement

The main factors affecting accurate blood analysis results are:

- Not remixing the sample. If the cartridge is not filled immediately after drawing blood, the blood must be remixed thoroughly. (Mix tubes by gentle inversion 7 times and syringes by rolling between the palms for at least 5 seconds in two directions.)
- Exposing the sample to air when measuring pH, PCO_2 and PO_2
- Time delays before filling the cartridge
- Drawing a sample from an arm with an I.V.
- Samples collected in vacuum tubes with anticoagulant other than lithium or sodium heparin
- Syringe for pH, PCO_2 and PO_2, with air bubbles in sample

Blood Analysis Module (M1022A)

Description

The Blood Analysis Module M1022A uses blood analysis technology from i-STAT® Corporation. The module is used together with i-STAT single-use, disposable cartridges for point-of-care determination of specific analytes in whole blood.

Measurements

Depending on the cartridge configuration, a subset of the following measured and calculated values will be displayed:

Measured

pCO_2
pO_2
pH
Glucose
Sodium
Potassium
Chloride
Ionized Calcium
BUN or Urea
Hematocrit

Calculated

HCO_3
Base excess (BE)
Oxygen Saturation (sO_2)
Anion Gap
Hemoglobin (Hb)
Total Carbon Dioxide (TCO_2)

Components

The Blood Analysis Module M1022A consists of the following major functional components:

Table 2-9 Major Blood Analysis Module Components

Component	Description
Mechanical System	A DC gear motor drives all mechanical system parts.
Sensor Interface	Amplifies the signals from the sensors so that they can be further processed by the main electronic circuits.
Analog to Digital convertor	An A/D convertor converts all analog signals into digital form for input to the microprocessor. An analog signal multiplexer makes it possible for the microprocessor to measure eight different types of analog signals.

Block Diagram

Figure 2-20 shows the block diagram of the blood analysis module

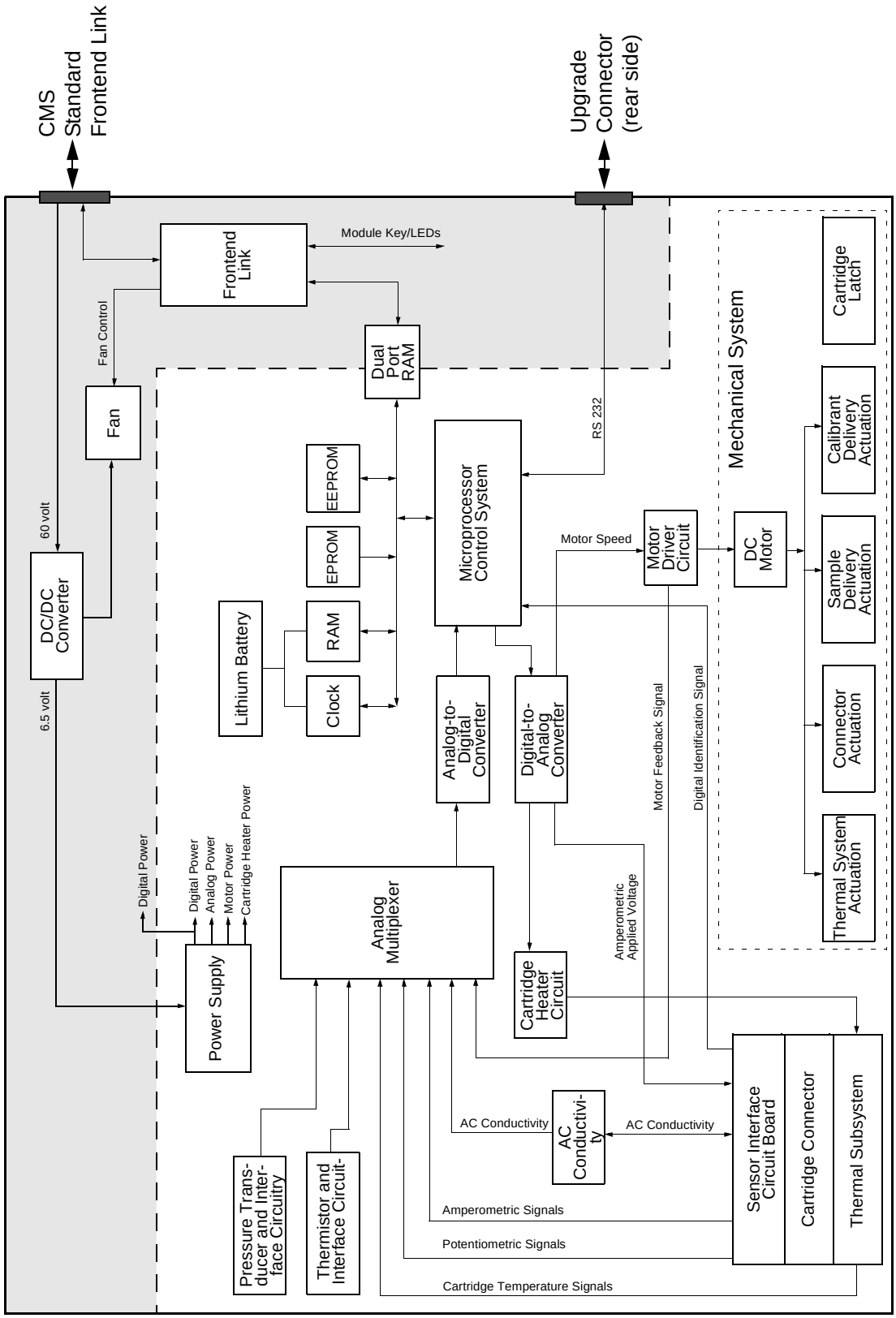


Figure 2-19 BAM Module - Hardware Block Diagram

Theory of Operation

1 Electrical signals from the sensors on the cartridge are conducted from the contact pads, through the internal connector in the module, to the sensor interface circuits. These circuits amplify the signals from the sensors so that they can be further processed by the main electronic circuitry.
Four signals are relayed to the main electronic circuits:

- a multiplexed potentiometric signal line
- a multiplexed amperometric signal line
- an AC fluid conductivity signal
- a digital identification code for the type of cartridge

2 An analog-to-digital convertor converts all analog signals into digital form so that the microprocessor can process the signals. An analog signal multiplexer makes it possible for the microprocessor to measure eight different types of analog signals:

- the potentiometric signals from the sensor interface
- the amperometric signals from the sensor interface
- a DC conductivity signal
- the power supply voltage
- a thermistor signal representing the internal temperature of the module
- a motor feedback signal used to control the speed of the mechanical motion
- cartridge temperature signals used to control the cartridge temperature to 37°C
- a pressure transducer signal representing the barometric pressure of the environment

3 The microprocessor control system manages all functions of the module. It accesses three types of memory storage devices. “FLASH” EPROM stores the software in the module. The RAM, which is backed up by an internal lithium battery, is used for temporary storage of sensor signals measured during operation and for storage of test records. Another EEPROM stores factory calibration information, the instrument serial number and a cumulative count of uses. Neither of the EEPROMS rely on the lithium battery for maintaining information.

4 The module creates and applies two types of signals to the sensors: a digital-to-analog convertor generates a voltage which is applied to amperometric sensors, and the AC conductivity circuit generates an AC excitation signal which is applied to the conductivity sensors. The digital-to-analog convertor also provides voltages to the motor driver circuit.

5 A DC motor drives all the mechanical system components:

- a connection actuator which brings the module internal connector into contact with the contact pads on the cartridge
- a calibrant delivery system
- a sample delivery system
- a thermal system actuator which brings the module's thermal controller into contact with heater elements on the back of the cartridge.

In addition, a latching mechanism locks the cartridge in place upon insertion.

Blood Analysis Features

Figure 2-20 shows the user controls and connectors for the Blood Analysis M1022A module. The descriptions of the numbered items are below the figure.

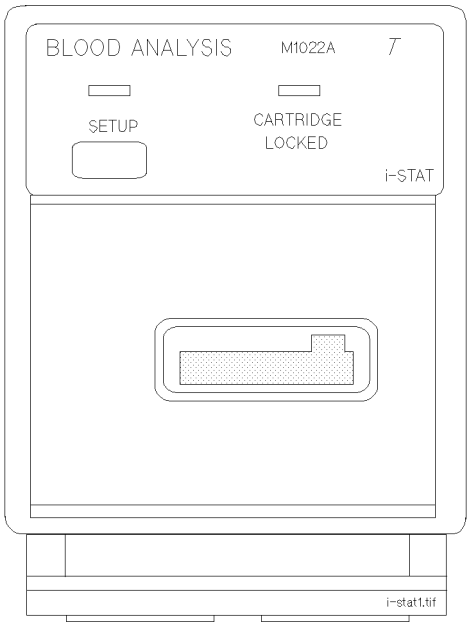


Figure 2-20 Blood Analysis Module Controls and Connectors

User Controls

1 **Blood Analysis Setup Key:** This is a single-press key used to enter the Blood Analysis setup screen. If no measurement is running when the key is pressed, you will enter the Blood Analysis window where the results of the last measurement are displayed.

2 **Blood Analysis Setup Indicator:** this is a green LED which will be lit when in the Blood Analysis screens.

3 **Cartridge Locked Indicator:** This green LED will be blinking when a cartridge is being processed in the module. The cartridge must remain in the module until the LED goes off, showing that the analysis is complete.

Connectors

4 The cartridge slot where a cartridge is inserted for processing.

5 (Rear Panel) **RS232 connector** for upgrade purposes

Safety There are no patient-applied parts in the Blood Analysis Module. This module complies with UL544, IEC 601-1, CSA C22.2 No. 125-M84

Blood Analysis Module - Software Update Requirements

The software is divided into two parts - the application software and the standardization software (CLEW). Software updates are required regularly to re-establish standardization values. Each update is delivered to the customer with full instructions for performing the update on the module. The delivered software consists of DOS executable files and does not require any other files to run.

The software can be run on a Central Data Station or another IBM-compatible PC. The connection to the module requires:

a) with CDS - connecting one of the RS232 cables (for IR Links) to the module

b) with an IBM-compatible PC - connecting a special adapter connector (M3663A for standard PC COM1) and modular data cable (e.g. M3642A #A03) to the module.

Blood Analysis Module Exercises

1 What type of sample does the Blood Analysis module require?

a. Plasma
b. Diluted whole blood
c. Undiluted whole blood

2 How are calculated results indicated on the results screen?

a. Marked with?
b. Marked with *
c. Marked with ‘

3 In amperometric measurements a current is generated by oxidation or reduction processes in the test system. Is the current generated?:

a. Directly proportional to the concentration of analyte
b. Inversely proportional to the concentration of analyte
c. Inversely proportional to the concentration of red blood cells

4 The connector for making software updates is situated:

a. On the front of the module
b. On the module rack
c. On the rear of the module

Answers

1. c.
2. c.
3. a.
4. c.

VueLink Module Concepts

VueLink Module

Description

The VueLink Module is used to connect an external device (such as a ventilator, gas analyzer, or stand-alone parameter monitor) to the CMS. The module provides a combined RS232 and analog interface to collect information from external devices that can be displayed, recorded, and trended on the system.

There are three different VueLink Module options:

1. **Auxiliary** - connects external stand-alone parameters to the monitor
2. **Ventilator** - connects ventilators to the monitor
3. **Gas Analyzer** - connects gas analyzers to the monitor

Measurements

VueLink Modules fall into two basic types:

Type A - can show up to 1 wave and 2 numerics
Type B - can show up to 2 waves and 6 numerics

Each module option is a fixed type as shown in the following table:

Option: Type:	**Aux A**	**Aux. Plus B**	**Ventil. B**	**Gas Analyzer B**	**Anesthesia Machine B**
Waves	1	2	2	2	2
Numerics	2	6	6	6	6

Each module enables only one external device to be connected at any one time, but supports the connection of several devices within a device group.

Components

The VueLink Module consists of the following major functional components:

Table 2-10 Major VueLink Module Components

Component	Description
Microprocessor	Controls the overall calculations and communication.
Input Protection Network	Provides ESD protection and protection against defibrillator voltage transients.
RS232 Driver	Converts the internal logic level to the RS232 level and vice- versa.
Digital Interface	Acquires data from external devices (ventilators, gas analyzers, etc.).
Analog Interface	Provides eight analog channels consisting of up to two wave channels, five numeric channels, and one alarm channel.

Block Diagram

Figure 2-21 shows the block diagram of the signal flow through the VueLink Module.

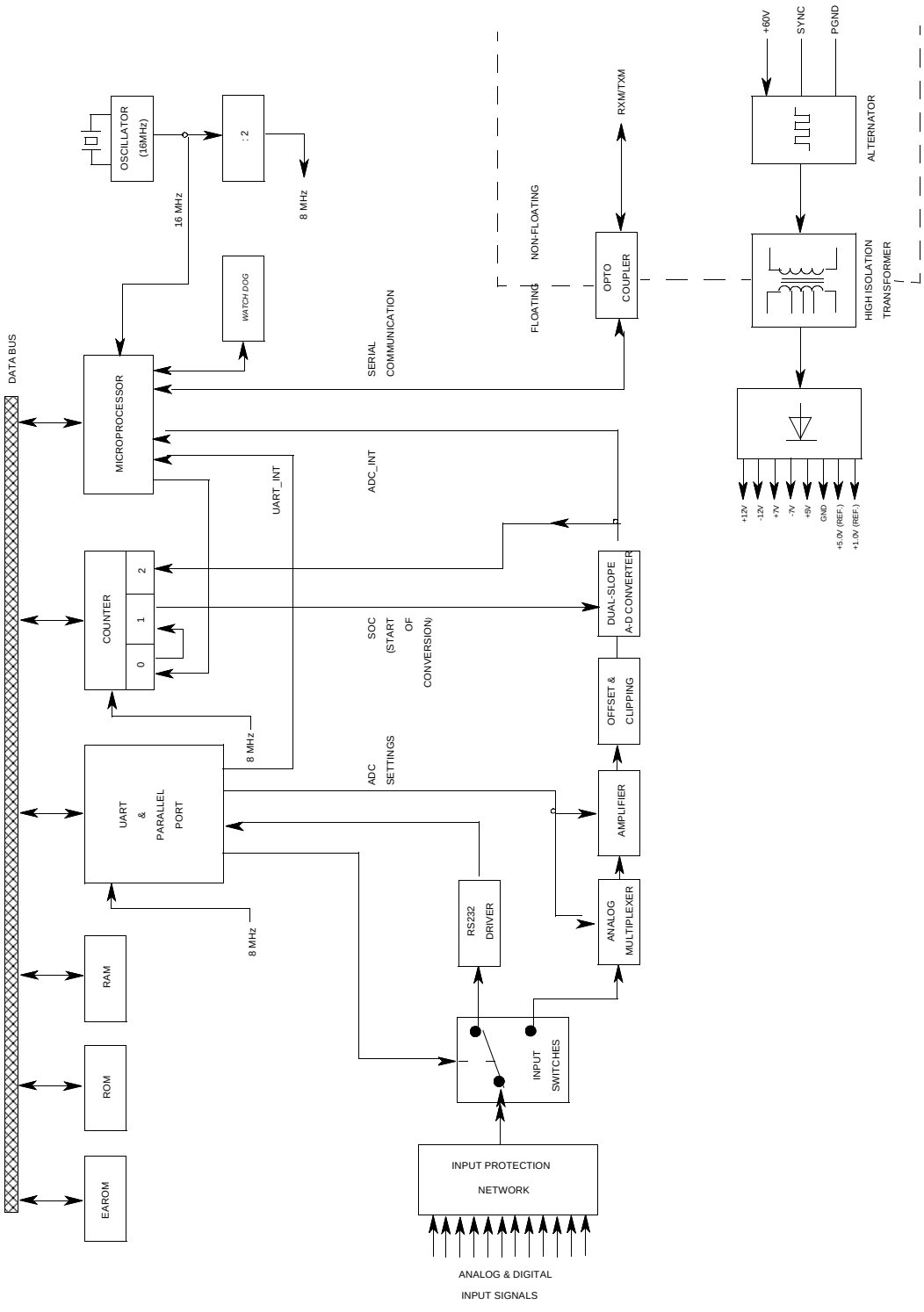


Figure 2-21 M1032 VueLink Module Block Diagram

Theory of Operation

The electrical signal must pass through three major sections of the Vuelink module, which are:

1 The Microprocessor which, in conjunction with the ROM, RAM, EPROM, and control logic, performs the following functions:

- Controls the input signal paths: the input switches connect the digital signals to the RS232 UART and the analog signals to the multiplexer
- Controls the analog multiplexer and the Analog-to-Digital converter
- Communicates with the RS232 UART
- Communicates with the rest of the CMS via the module link
- Converts external device-specific protocols to the internal standardized CMS protocol by using Device Drivers which are device-specific protocol translators.
- Controls the downloading and Flash-EPROM programming of device drivers via the built-in RS232 interface. A Flash-EPROM is used instead of a ROM or EPROM; the capacity of the EPROM supports several device drivers, and up to three device drivers can be selected by the user.

2 The RS232 Digital Interface, which acquires data from external devices (ventilators, gas analyzers, etc.). Typically, the data consist of waveforms, measured values, device settings, alarm status, and alarm and INOP information. The specific device drivers are converting these vendor/type specific data to the standardized CMS data types representing waveforms, numeric values, settings, alarm status, alarms, and INOPs.

3 The Analog Interface, which provides eight analog channels consisting of up to two wave channels, five numeric channels, and one alarm channel. Each channel can be adapted individually to the output voltage level of the external device. The adaptation is executed by hardware gain switching and/or software scaling controlled by the specific device driver. The alarm channel is also used to identify a cable disconnect status as long as the active level is different to zero Volts.

The analog input signals are fed from the input connector via the input protection network, the input switches, and an analog multiplexer to an input amplifier. All input signals are digitized sequentially using the dual-slope Analog-to-Digital converter.

M1032A VueLink Module Features

Figure 2-22 shows the user controls and connectors for the VueLink Module. Refer to this figure for the User Controls and Connector descriptions.

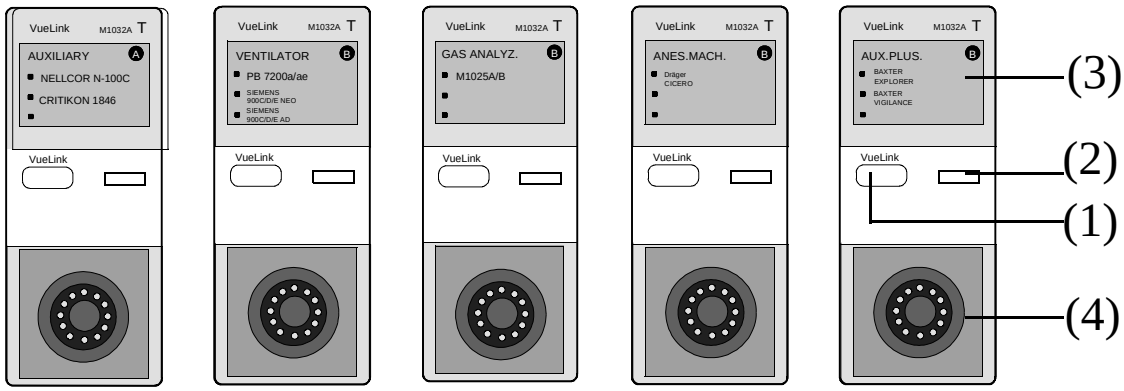


Figure 2-22 VueLink Module Controls and Connectors

User Controls

1 Setup Key: A single-press key used to enter the VueLink setup screen.

2 VueLink Setup Indicator: a green LED, which will be lit when in the VueLink Setup screen.

3 Labels: giving names of the external devices to which the VueLink Module can be connected, and an LED beside each label indicating the selected device.

Connectors

4 12-pin connector for use with external devices.

Safety

To ensure the safety of the patient, the patient-applied parts are isolated from ground by optical isolators and a transformer. In addition, the entire module is encapsulated in plastic.

This module complies with UL544, IED-601-1, CSA C22.2 No. 125. Patient leakage current is less than 10µA at 120V/60Hz.

Isolated patient connection to *Class 1* protection, Type *Cardiac Floating (CF)*.

There is also protection against damage from defibrillation and electro surgery.

VueLink Module Exercises

1. The VueLink Module options can be all but which of the following?

   a. Liquid
   b. Gas
   c. Ventilator

2. The Type A VueLink Module can show up to:

   a. one wave and six numerics
   b. one wave and two numerics
   c. two waves and two numerics

3. The VueLink Module RS232 Digital Interface acquires data from the:

   a. microprocessor
   b. analog interface
   c. external devices

4. The labels on the VueLink show the names of:

   a. VueLink Setup Screen options
   b. external devices to which the Vuelink Module can be connected
   c. internal VueLink Module components

Answers
1. a
2. b
3. c
4. b

EEG Module Concepts (CMS only)

EEG Measurement

Basics

The electroencephalogram (EEG) is the measurement of the electrical activity of the brain. This activity creates an electrical signal that, depending on the person's state of consciousness or well-being, produces characteristic waveforms. Although its origin is unclear, there is strong evidence that the signal is a summation of the tens of billions of active nerve cells (neurons) in the brain. The waves seen are generated from electrical potentials located on the surface of the brain. These potentials are recorded by placing electrodes on the scalp.

The following terms and concepts are important to understanding EEG monitoring.

EEG Channels

Standard EEG "machines" are capable of recording many channels, 16 to 32 or more. These channels are produced by electrode placement (see electrode placement). Routinely, the electrode pairs are placed over specific areas of the brain frontal, temporal, parietal, occipital, etc. Then, just like ECG monitoring, the voltage differences between the electrodes are measured.

With most bedside EEG monitors, fewer channels (2 to 8) are recorded. Logic tell us that the more channels you record, the more information you derive.

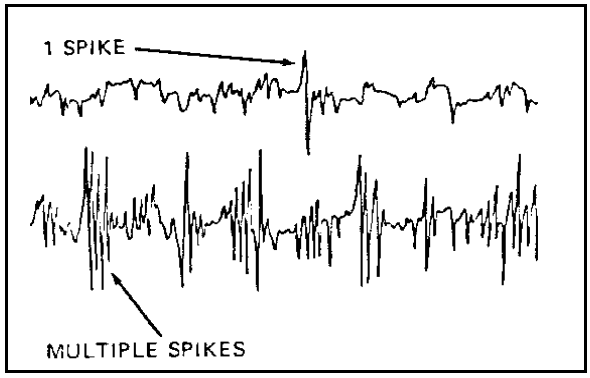
EEG Signal

The EEG signal is extremely low voltage, measured in microvolts, compared to the ECG, which is measured in millivolts. The EEG voltages are very minute and must be amplified. Since 60 Hz noise is approximately 10000 times stronger, the signal is also filtered.

Brain Waves

The EEG varies with alterations in the function and metabolism of the brain, but there are classic characteristics.

- **Waves** - The electrical potentials change in a rhythmic, repeating fashion. These changes are recorded as waves.
- **Frequency** - The pattern of waves, or rhythm, is called the frequency, and is expressed in Hertz (Hz) or cycles per second.
- **Amplitude** - This is the voltage measurement of the EEG wave from the top of the peak to the bottom of the peak.
- **Spike** - A spike is a fast wave with steep slopes on each side that may appear randomly or in bursts. It is an abnormal sign which can indicate the location of pathology. It's often seen with epilepsy or enflurane overdose.



The changes in the EEG waves can be:

- **Background** - The pattern indicating what the brain is doing all the time.
- **Transient** - A single wave, such as a spike, that differs from the background pattern.
- **Paroxysmal** - A sudden burst of change, such as multiple spikes, which return to normal.

Though it takes significant training to provide a clinical interpretation of the EEG, some basic techniques used to describe the EEG can be mastered and used to communicate changes in the EEG. The four areas used to describe the EEG are frequency, amplitude, symmetry and patterns.

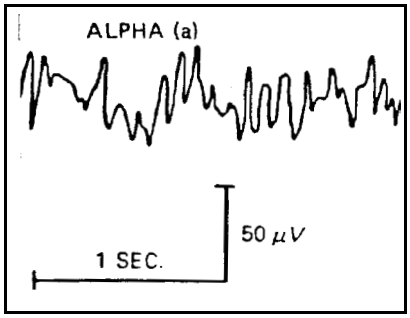
Frequency

Specific brain wave patterns are recognized by analyzing the EEG signal in relationship to its frequency and amplitude. Most EEG signals are in the 1 to 30 Hz. range.
The four most common frequency bands for classifying EEG signals are Beta, Alpha, Theta and Delta.

Alpha

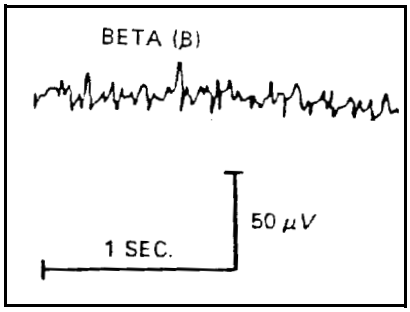
Alpha waves are what the spontaneous EEG looks like in the normal, awake, relaxed with eyes closed adult. It has the appearance of rather large, smooth, and rhythmic waves. These waves suggest a high degree of electrical coordination even in the idle brain.

Alpha frequency is defined as 8 to 12.5 Hz.



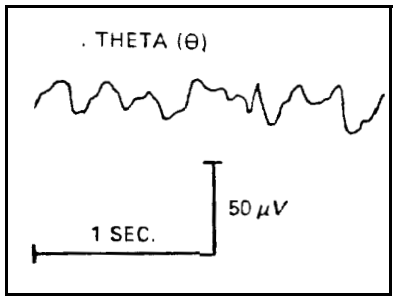
Beta During periods of conscious effort, the EEG rapidly desynchronizes and is replaced by the low amplitude, high frequency “jumbles” of Beta.

Beta frequency is defined as 13 to 30 Hz.



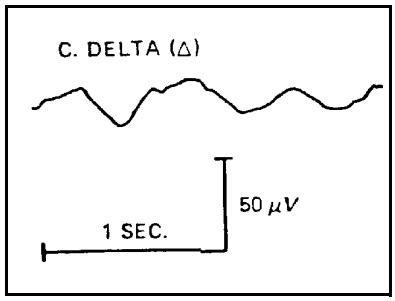
Theta Theta waves are usually not seen in the awake alert adult except in the presence of pathology. They can also be seen in certain stages of anesthesia.

Theta frequency is defined as 4 to 8 Hz.



Delta Likewise, Delta waves are usually not seen in the awake alert adult except in the presence of pathology, coma and certain stages of anesthesia.

Delta frequency is defined as 0.5 to 4 Hz.



Amplitude

Amplitude refers to the height of the EEG and is measured in microvolts.

- Low Amplitude: < 20 microvolts
- Medium Amplitude: 20 to 50 microvolts
- High Amplitude: > 50 microvolts

Symmetry

The EEG is generally symmetrical over both hemispheres. Anesthetics and metabolic problems affect the hemispheres symmetrically. Where there is a loss of symmetry, there may be pathology or ischemia in one of the hemispheres.

Patterns

Many things can change the EEG. The most common things that change the EEG are drugs, seizures, cerebral ischemia and coma.

Drugs

Most anesthetics have an effect on the EEG since the target organ of their action is the brain. Typically as the dose increases the EEG initially slows and the amplitude increases, followed by a decrease in amplitude until the EEG becomes isoelectric. However, some anesthestics cause the normally continuous EEG to break up into successive bursts with periods of almost flat EEG in between. This is called burst suppression and is seen with barbituates used for brain suppression.

- Initial amplitude increases and frequency slows
- Decreases in amplitude
- isoelectric and/or burst suppression

Seizures

EEG is the definitive way to diagnose a seizure. Seizures come in many different varieties but many start with a rhythmic pattern in one or a few channels and progress to a very high amplitude pattern and then back to the pre-seizure EEG. Some seizures have a period of almost flat EEG following the seizure.

- Rhythmic pattern
- Gradual build
- Multiple channels with high amplitude
- Return to normal or a brief isoelectric period

Coma

There are several patterns that can be seen in coma depending on the etiology, depth and prognosis of the coma. In most comatose states there is a diffuse slowing of the EEG. In general a variable EEG is a good prognostic sign and monotonous EEG is considered a poor prognostic sign.

- Patterns depend on the etiology, depth and prognosis of coma
- Generalized slowing
- Variable EEG = Good prognosis
- Monotonous, invariable EEG = poor prognosis

Cerebral Ischemia

Lack of oxygen or hypoxia to the entire brain causes a generalized slowing over the entire cerebral cortex. Slowing of the EEG one area of the brain is seen in embolic

phenomenon such as stroke or clamping of the carotid artery. If prolonged the EEG becomes isoelectric or flat.

- Generalized slowing if hypoxic
- Focal slowing if ischemic event
- Progresses to isoelectric if prolonged

EEG Module

Description

The M1027A EEG Module monitors the patient's cerebral function by measuring the electrical activity of the brain. EEG monitoring assists in diagnosing many neurological illnesses and diseases, such as epilepsy, tumor, cerebrovascular lesions (e.g. seizures). ischemia and problems associated with head trauma.
In the Operating Room, EEG monitoring provides a record of the adequacy of anesthesia and information about cortical blood flow.

Measurements

The EEG module produces two channels of EEG realtime waves which can be displayed and recorded. They are labeled EEG1 and EEG2. For each channel, the following eight numerics are calculated:

- **Spectral Edge Frequency (SEF)** -The frequency below which a defined percentage (configurable) of the total power lies.
- **Mean Dominant Frequency** (MDF)
- **Peak Power Frequency (PPF)** - The frequency with the highest power.
- **Total Power** (TP) - Power content of a channel, i.e. the voltage squared over an impedance of 1 ohm.

Percentage of total power in each frequency band:

- **Alpha** - Alpha waves represent the EEG in a normal awake adult. Their frequency is defined as 8-13 Hz.
- **Beta** - Beta waves represent the EEG during periods of conscious effort. Their frequency is defined as 13 to 30 Hz
- **Theta** - Theta waves are usually seen in the presence of pathology. Their frequency is defined as 4 to 8 Hz
- **Delta** - Delta waves are seen in the presence of pathology, coma and certain stages of anesthesia. Their frequency is defined as 0.5 to 4 Hz

Two of these numerics can be selected for continuous display, trending and recording. The selected numerics are displayed in large digits next to their respective wave. If one of the selected numerics is a frequency (i.e. SEF, MDF or PPF), a trend line for this frequency will be displayed in the Compressed Spectral Array (CSA). See section below for details.

Components

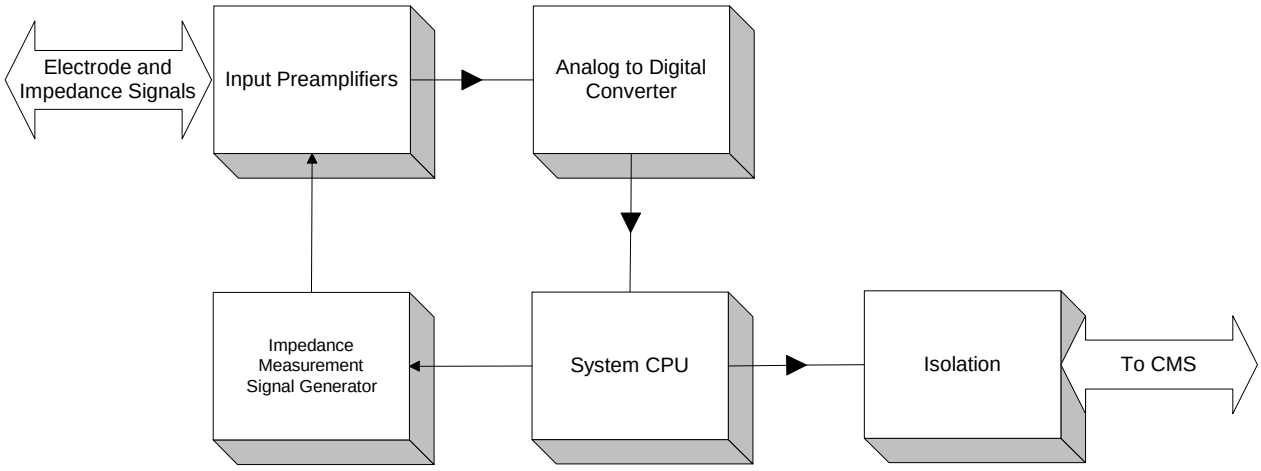
The EEG Module consists of the following major functional components:

Table 2-11 Major EEG Module Components

Component	Description
Input Preamplifiers	The input preamplifiers provide high impedances to the electrodes connected to the patient's head. They pre-amplify the input lead signals analogically. They achieve pre-filtering of the input lead signals in order to perform an anti-aliasing function prior to digitizing the signals.
Analog to Digital Converter	The analog to digital converter converts each single electrode voltage delivered from the input preamplifiers into digital form and transmits the results to the system central processing unit (CPU).
Impedance Measurement Signal Generator	The impedance measurement signal generator is made up of two AC-currents of different frequency. The CPU generates said frequencies. The voltages are converted into two very small currents fed into the electrodes.
Central Processing Unit (CPU)	The central processing unit (CPU) processes all input signals from the EEG electrodes. It filters said signals, calculates the compressed spectral array data and derives the single electrode impedance measurement values. The CPU provides a small multi-tasking internal operating system to control internal and external appliances. It controls the non-volatile read / write storage device and ensures the system integrity, i.e. it detects possible failure conditions and generates appropriate error messages. All system events are handled and it acts as an interface between the plug-in module and the CMS.
Isolation	Two functions are performed by the isolation block: It delivers the necessary power from the CMS to the plug-in module and its optical communication path for the data transfer from the CMS and to the CMS. It isolates the patient electrically from the CMS.

Block Diagram

Figure 2-21 shows the block diagram of the signal flow through the EEG Module.



Theory of Operation

Introduction

There are drawbacks to continuously monitoring the raw EEG signals with conventional EEG machines. These include the need for constant analysis of the waves by a skilled technician and the acquisition of volumes of recording paper. Therefore the use of computerized processing, called frequency analysis, is the method of choice.

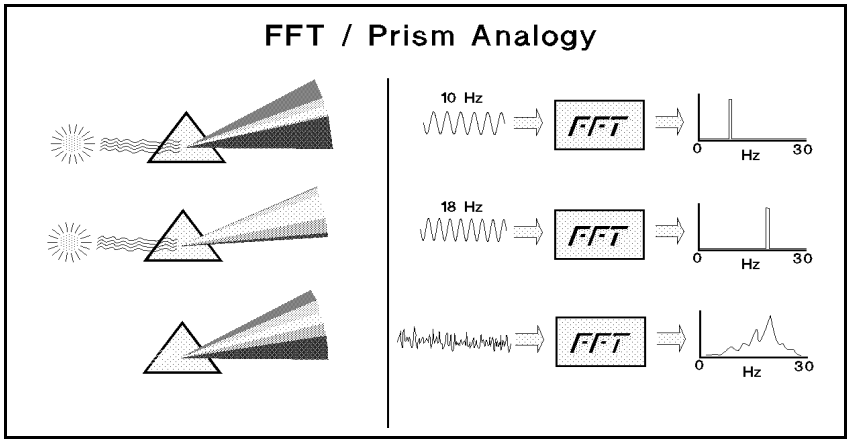
Frequency analysis takes the raw EEG waves, mathematically analyzes them and breaks them into their component frequencies. The method of doing this is called Fast Fourier Transform or FFT.

FFT

In Fourier analysis, changes in the EEG are more easily detected because the original, complex signal is digitized for computer analysis and converted into a simplified waveform called a spectrum. It is then separated into frequency bands: delta (<4 Hz), theta (4 to 8 Hz), alpha (8 to 13 Hz), and beta (>13 Hz). The redistribution of electrical activity in the brain among certain frequency bands or the predominance of one band over the others correlates with specific physiologic and pathologic conditions.

FFT Computation

To compute the FFT, the module samples the continuous EEG signal periodically and stores the value. Then by using a number of samples, the distribution of energy at each frequency is computed. This results in a frequency spectrum for each sample.



Compressed Spectral Array

After processing the EEG by FFT, the resulting spectrum is displayed. The method of display is Compressed Spectral Array (CSA). CSA compresses a large amount of data into a compact, easy to read trend.

The CSA “stacks” each sample’s spectrum one right below the other, usually at 2 second intervals. Hidden lines are removed for clarity. This way, it’s easy to pick up changes in the frequency and amplitude of each sample over longer periods of time.

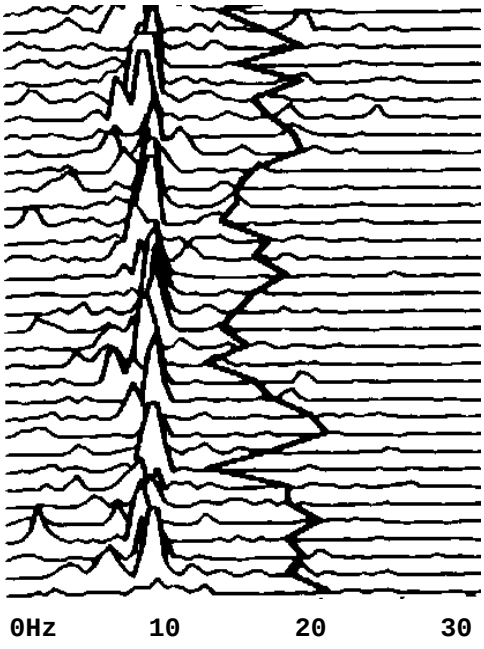


Figure 2-23 Compressed Spectral Array (CSA)

Impedance

The main quality indicator for the measured EEG signal is the electrode-to-skin impedance. During normal EEG monitoring, electrode-to-skin impedance is measured continuously and disconnected electrodes are detected. An INOP message is displayed if the user-adjustable impedance threshold is exceeded. The impedance value for each single, independent electrode is displayed in the Electrode Impedance Task Window and the Electrode Montage Task Window.

Electrode Application

EEG Electrode Location Terminology

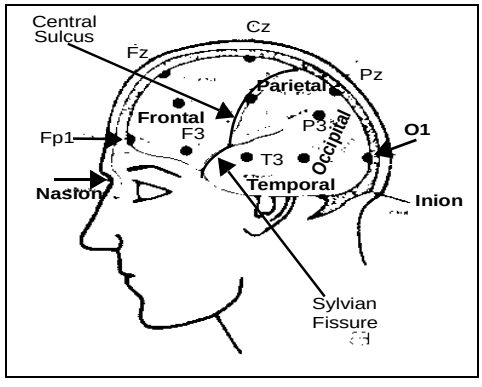
The International 10/20 System of Electrode Placement is a procedure for the measured location of equally spaced electrodes on the scalp. This system is based on the relationship between the cortical areas of the brain and the location of the EEG electrodes that reside directly above them.

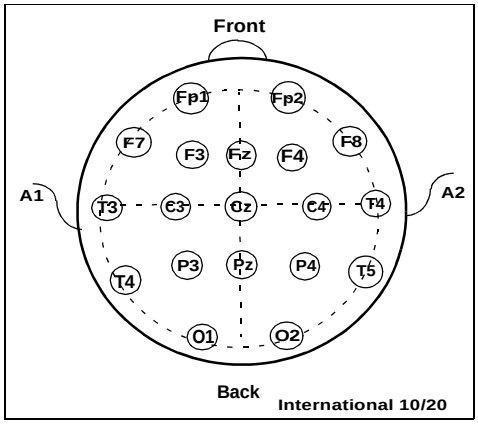
Traditionally there are 21 electrode locations in the 10/20 system. All of these are needed for diagnostic recordings; however in EEG monitoring a sub-set of these electrodes may be used to determined the neurological status of the patient.

Each location is marked with a unique letter/number combination. The letters correspond to the cortical areas of the brain where they are located. The numbers are odd for the left positions, even for the right positions, and increase as they move away from the midline (which is designated as Z for zero).

When using a EEG monitor locating the proper place for electrodes can be simplified. The electrode pair can be marked using landmarks on the head such as the hairline, ears and top of the head to approximate the 10/20 locations.

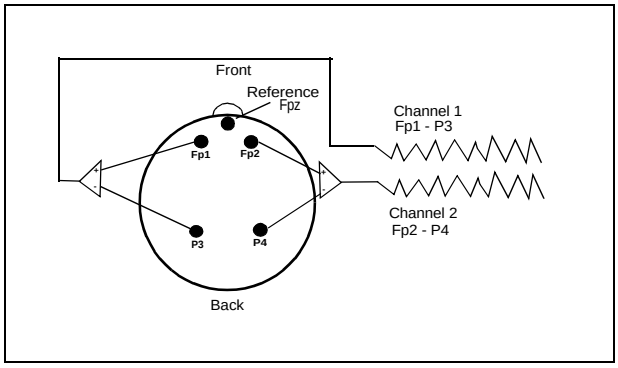
A pattern of electrodes on the head and the channels they are connected to is called a montage. There are many different combinations of electrode pairs. However, when dealing with a small number of channels there are only a few things you need to know.





They are:

- Montages are always symmetrical.
- Choose a montage based on clinical setting.
- A reference electrode is generally placed on a non-active site such as the forehead or earlobe.



Montage

EEG Module Features

Figure 2-24 shows the user controls and connector for the EEG Module. The parts are described following the figure.

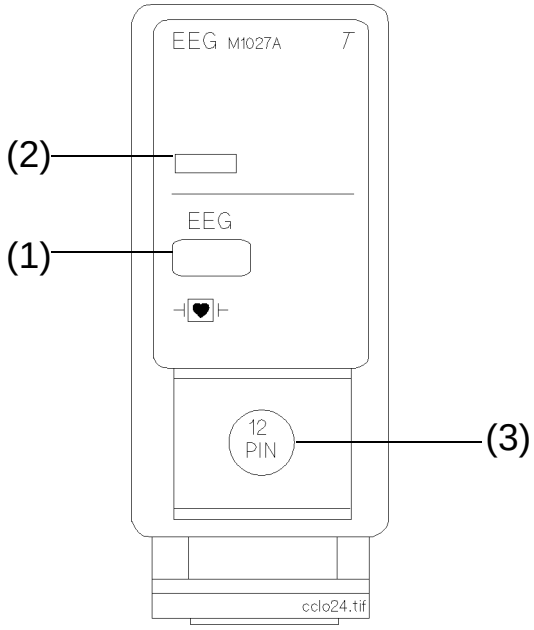


Figure 2-24 EEG Module controls and connectors

User Controls

1 **Setup Key**: This is a single-press key, used to enter the EEG setup screen.

2 **Setup Indicator**: This is a green LED, which will be lit when in the EEG setup screen.

Connectors

3 The EEG M1027A uses a standard **12-pin connector** for use with an EEG trunk cable and EEG electrodes.

Safety

To ensure the safety of the patient, the patient applied parts are isolated from ground by optical isolators and a transformer. In addition, the entire module is encapsulated in plastic.

This module complies with UL544, CSA No. 125-M1984 (for use with model M1165/66/75/76) and UL2601-1, CAN/CSA-C22.2 No.601.1-M90 (for use with model M1167/77), IEC-601-1, IEC-601-2-26. Patient leakage current is less than 10µA at 120V/60Hz.

It has an isolated patient connection to Class I protection, Type Cardiac Floating (CF).

There is also protection against damage from defibrillation and electro surgery.

BIS Module Concepts

BIS Measurement

Introduction

The **Bispectral Index® (BIS®)** [1]is a continuous processed EEG parameter that provides a measure of the state of the brain during the administration of anesthetics and sedatives. BIS® was designed to correlate with "hypnotic" clinical endpoints (sedation, lack of awareness and memory) and to track changes in the effects of anesthetics on the brain. To properly interpret the clinical relevance of BIS® responses, users should familiarize themselves with this new parameter and its dynamic changes in response to common interventions.

This section briefly describes the use of BIS® for monitoring the effects of anesthetics and sedatives. The goal is to provide a concise summary of factors to consider about BIS® monitoring in order to assure appropriate interpretation and use of the information provided by this new parameter.

Depth of Anesthesia

Previous research on neurophysiological monitors of "depth of anesthesia" has often suffered from lack of a clear definition of what constitutes adequate anesthetic depth. It has been proposed that there are various distinct clinical goals of optimum balanced anesthesia, hypnosis, lack of recall, analgesia, and muscle relaxation /areflexia (Figure 2-25).

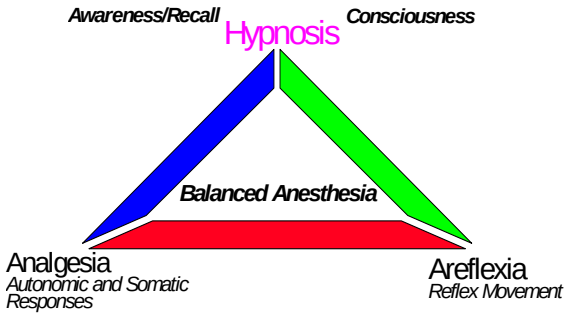


Figure 2-25 Components of Anesthesia

Given these multiple goals, the concept of a unitary "depth of anesthesia" may need to be revised to reflect the separate clinical components of the ideal anesthetic state. Consequently, monitoring of anesthesia may require separate measures of each of these components, i.e. hypnosis, obtunding of responses to noxious stimulation, and neuromuscular blockade. Current clinical practice relies primarily on vigilant

1. BIS and Bispectral Index are registered trademarks of Aspect Medical Systems

observation of hemodynamic, autonomic and somatic responses as endpoints for anesthetic titration. Unfortunately, none of these parameters is a direct measure of how asleep or awake (“hypnotic”) the patient is. While these physiological signs may correlate with the hypnotic state in some instances, many factors can interfere with this relationship:

- The combination of multiple agents with varying effects and sites of action
- Synergistic effects of the drugs
- The cardiovascular and hemodynamic status of the patient
- The use of drugs that attenuate cardiovascular responses (e.g. vasodilators, alpha and beta blockers, etc.)
- The varying amounts of noxious stimulation to which the patient is subjected. Hemodynamic, autonomic and somatic measures of anesthetic effect react when stimulus strength significantly exceeds the level of sensory suppression provided by hypnotics and analgesics, but this dynamic balance can vary considerably during surgery
- Dissociation between the dose required to achieve the therapeutic effect (hypnosis) versus undesired cardiovascular effects. Traditional vital signs provide a measure of cardiovascular tolerance and indicate when significant autonomic responses have occurred, but often do not accurately reflect the state of the brain. This sometimes results in the use of anesthetics to manage the hemodynamic status of patients rather than their hypnotic state.

Despite the absence of a reliable “depth of anesthesia” measure, the practice of anesthesia remains one of the safest and most effective in medicine. However, a quantitative measure which differentiates brain responses from somatic, autonomic and hemodynamic responses can provide useful information which contributes to improved safety, effectiveness and efficiency in anesthetic delivery.

Monitoring the hypnotic effects of anesthetics with BIS®, in combination with current monitored parameters and clinical signs, has been shown to allow better balancing of hypnotic and analgesic administration. Demonstrated benefits include:

- Continuous monitoring for the risk of awareness
- Better management of responses to surgical stimulation
- More rational selection of drugs

Additional studies have shown that monitoring with BIS® can also aid the anesthetic provider in delivering the most appropriate doses of hypnotics and analgesics, resulting in:

- Faster wake up and recovery
- More cost-effective use of drugs
- Fewer unwanted intraoperative responses

The Bispectral Index (BIS) and Depth of Anesthesia

Because BIS® reflects changes in anesthetic dosing, it might be assumed that this information can be used in isolation to gauge depth of anesthesia. However, utility of the BIS® depends on the users expectations of "depth of anesthesia" monitoring and the goals of the particular anesthetic regimen being used. It is recommended that users integrate the information provided by BIS® with other commonly used indicators of anesthetic effect to achieve their clinical objectives. In order to facilitate this process, several performance characteristics must be taken into consideration.

BIS Response to Commonly Used Anesthetic Drugs

As a measure of the hypnotic state of the patient, or "depth of hypnosis", BIS® will usually decrease when doses of anesthetics are increased and increase when doses are being reduced. If the drug being used has good hypnotic properties (e.g., propofol, potent inhalational agents, thiopental, etc.), lower BIS® levels will be observed at concentrations typically used for general anesthesia (e.g. 1% isoflurane, 150 ug/kg/min propofol). In the presence of a constant level of stimulation, BIS® thus provides an excellent pharmacodynamic measure of the individual's brain response to a given drug concentration which tracks the clinical state. This means that sensitive patients will show bigger decreases in BIS® than those who are more tolerant to a given dose, as demonstrated in an extensive series of volunteer and patient trials. Lower BIS® values are associated with progressive suppression of brain activity and a correspondingly lower probability of response to a given stimulus, assuming that the stimulation is consistent. For example, patients with BIS® levels of 60 are unlikely to respond to verbal command, but may become aroused when given a painful stimulation. These clinical arousals (i.e. waking up) of a patient can be followed by observing increases in the hypnotic BIS® level.

In general, opioids do not have a significant influence on the patient's state of consciousness or BIS® at concentrations used to achieve adequate analgesia in routine general surgery. Opioid analgesics, or regional blocks, can be very effective at attenuating sensory input, thereby substantially reducing the intensity of stimulation and preventing subsequent patient responses. If low levels of hypnotics are used in this situation, patients could be awake or lightly sedated hypnotically (BIS® 70-80) without exhibiting any signs of inadequate anesthesia as measured by traditional signs.

Changes in the Bispectral Index in Response to Drugs and Stimulation

Like cardiovascular and somatic responses, the hypnotic state of patients undergoing surgery is influenced by the intensity of stimulation that is applied. In the absence of stimulation, relatively little drug is required to induce and maintain loss of consciousness. During the course of a surgical procedure, however, the balance between the intensity of stimulation and sensory suppression may be constantly changing. Figure 2 presents a simplified diagram outlining how stimulation and

anesthetic suppression may contribute to determining the hypnotic state at any given point in time.

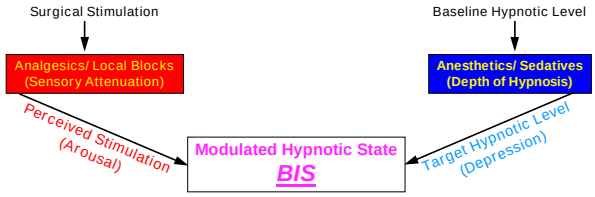
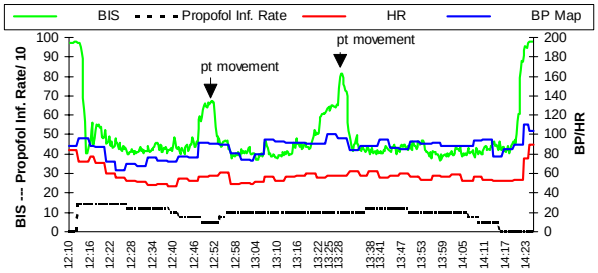


Figure 2-26 Factors influencing the modulated hypnotic state during surgery

Painful surgical stimulation can be attenuated by local anesthetics or analgesics at several levels of the sensory pathway. The resulting amount of stimulation reaching the brain can then be thought of as the perceived stimulus. A net increase in the perceived stimulus can lead to a lightening in the patient's hypnotic state, while a net decrease can result in a return to deeper hypnotic levels. This phenomenon can often be seen by observing real-time changes in BIS® when constant anesthetic levels are being maintained. Oscillations in BIS® can potentially provide a direct measure of the brain's response to stimulation and an alternative measure of responsiveness/ reactiveness similar to other vital sign endpoints.

The following **example case** illustrates several different patterns of BIS® changes that can occur during a typical anesthetic regimen.



At the start of the case, following rapid sequence induction with propofol and alfentanil, BIS® falls rapidly from an awake value of 98 to below 50. Conversely, a rapid rise in the BIS® after propofol is discontinued occurs at the end of the case, just prior to the time when the patient opens her eyes and becomes responsive. In both instances, **BIS® clearly tracks the expected changes in propofol effect** which occur at these times. Intraoperatively, however, additional types of responses are evident:

- **A slow upward trend** (>10 points over several minutes) prior to the two movement events.
- **A sudden rise** (5-30 seconds), such as the increase associated with the second movement response.

- **Cyclical oscillations** which occur during apparent steady-state anesthetic delivery conditions.

A slow upward trend in BIS® usually is associated with a progressive lightening of the hypnotic state. This can be due to one or more of the following factors: pharmacokinetic redistribution of a drug from its effect site in the brain, as might occur following a rapid bolus drug administration; a reduction in hypnotic effect due to a disruption in drug delivery; increased tolerance to the drug effect; or a slow increase in the level of stimulation. Conversely, a slow downward trend in BIS® can indicate a deepening of the hypnotic state of the patient. Possible causes include: reduction in surgical stimulation; hypnotic or analgesic drug accumulation; inadvertent or unrecognized increases in drug delivery, or progressive hypothermia, especially as might occur during long cardiac procedures.

When **large, abrupt changes in BIS®** occur, it is important to rule out that they are not triggered by artifact. Assuming that there is no obvious artifact, such changes are usually caused by significant changes in stimulation, resulting in patient arousal. Users should be cautious about using a particular BIS® value in isolation as a **predictor** of such patient responsiveness, because arousal can potentially occur from any hypnotic level. Anesthetic techniques that rely heavily on hypnotics and use little or no opioid allow highly variable levels of perceived stimulation, which can arouse the patient even if the BIS® is low. This causes a rapid hypnotic lightening, reflected by a significant increase in the BIS®. Such increases in BIS® can occur prior to the appearance of other clinical signs, such as hypertension or movement, but in some cases the 30-second time averaging used in the display of BIS® data may result in some lag in tracking this response. In contrast, a sudden reduction in stimulation (for example, tourniquet release or completion of a stimulating surgical dissection) can lead to a significant drop in BIS®, especially if high doses of hypnotics and analgesics were used to maintain adequate hypnosis and hemodynamic/autonomic status while the stimulus was large.

Cyclic oscillation in BIS® under steady state conditions may provide an indication of the shifting balance between sensory suppression and stimulation. Clinical experience suggests that smaller volatile changes are seen when sufficient levels of narcotics are used as part of the anesthetic regimen to reduce the effects of stimulation. In volunteer studies, higher BIS® variability was observed when sedatives were used alone compared to when alfentanil was used concurrently.

Several **other physiological factors** may also alter the hypnotic state of the patient. As a result, changes in BIS® may occur even when all obvious determinants of hypnosis remain unchanged. Some of these additional factors include:

1. Ischemia or severe hypoxia, resulting in a decrease in the BIS® if severe enough to cause global EEG slowing or outright suppression. It is important to bear in mind, however, that the frontal montage used for BIS® monitoring usually will not detect episodes of focal ischemia caused by embolic events.
2. Hypothermia (< 33^{o}C) will generally result in a corresponding decrease in BIS® levels as brain processes slow. More profound hypothermia used during cardiac bypass procedures will cause suppression of the EEG and, consequently, a very low BIS®.

3. Artifact.

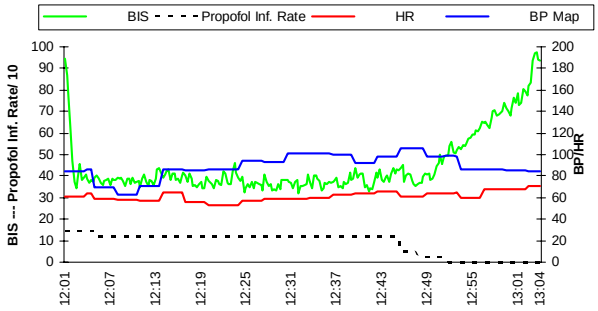
Therefore, in order to properly interpret unexpected BIS® changes, it is important to consider all current clinical signs, ongoing stimulation, drug delivery and raw EEG signal quality.

Using BIS to Optimize Anesthetic Delivery

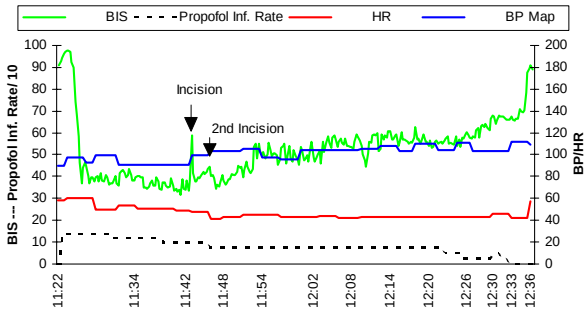
As discussed above, BIS® provides ongoing information about the hypnotic state which can be useful in determining patient response to anesthetics and stimulation. Since there is no single anesthetic technique that is appropriate for everyone, optimum use of the BIS® will depend on clinical goals of the anesthetist. **Based on this consideration, there is no single BIS® value or range that can be recommended or is appropriate for all patients or conditions.** For those who prefer to keep their patients deeply anesthetized to suppress all unwanted responses, BIS® can provide an opportunity for reducing the relative overdosing of the hypnotic state (BIS® <40) which may occur with this approach. Clinicians who seek to keep their patients light can utilize the BIS® response to help determine the minimum effective dose of anesthetic required by each individual to reduce the risk of awareness. For sedation during MAC cases with regional blocks, prevention of unnecessary sedation (BIS®<70) may be the monitoring goal. Because of this diversity in clinical need, most new users of BIS® monitoring benefit from first characterizing their standard practice using the BIS® in an observational fashion. During this initial evaluation phase, typical practice ranges and BIS® responses to various interventions can be observed in the context of the individual's own practice. In this way, opportunities for possible improvements in anesthetic delivery can be identified, while confidence in the information provided by the BIS® is established. The BIS® response can then be incorporated as an additional parameter to help guide appropriate anesthetic dosing adjustments to achieve the desired clinical goals.

Minimum Effective Dose Paradigm

A large multicenter clinical study involved use of the BIS® to help determine the minimum effective dose of anesthetics. Following induction and intubation, anesthesia is initially maintained using infusions of propofol (120 - 140 ug/kg/min) and alfentanil (0.5ug/kg/min) with 50% N_2O. As shown in the following example where the user was blinded to the BIS® value, a relatively deep (BIS®< 40) but stable anesthetic profile was maintained, resulting in a 11 minute recovery at the end of surgery.



While this was considered to be a very acceptable anesthetic outcome, further improvement in efficiency is possible, as shown in the following example.



In this example of BIS®-directed anesthesia, the propofol infusion rate is incrementally reduced in order to achieve a BIS® increase to about 55-60 and then maintained at the minimum dose (70 ug/kg/min) required to stay in this range until the last 15 minutes of the case, when a BIS® target of 60-70 is used. Since sufficient analgesia is provided by the opioid and N_2O, relatively low propofol infusion rates (i.e. < 100 ug/kg/min) are often sufficient to maintain adequate hypnosis. In this case, significantly less drug was used and the patient was awake and responding to questions within minutes.

This clinical research demonstrated that BIS® monitoring can consistently allow cost-effective intraoperative management of anesthetic drug delivery, resulting in significantly faster recovery and earlier eligibility for discharge from the PACU.

BIS Module

Description

The method for measuring Bispectral Index® (BIS®) is based on an algorithm developed by Aspect Medical Systems. The Bispectral Index® (BIS®) is a continuous processed EEG parameter that provides a measure of the hypnotic state of the brain during the administration of anesthetics and sedatives. The technology enables anesthesia providers to track a patient's level of consciousness and administer the appropriate amount of anesthesia for each patient, leading to improved drug titration, faster and more predictable patient wake-up times after surgery and improved patient recovery from anesthesia. The BIS® technology uses a sensor placed on the forehead to capture the EEG signals which are translated into a single number ranging from 100 (for wide awake) to zero (indicating absence of brain electrical activity).

Measurement

The BIS® application displays three numerical values on the main screen of the CMS or V24/V26:

- **Bispectral Index®**
- **Signal Quality Index**
- **Electromyography**

Additionally, the **Suppression Ratio** can be configured to be displayed in the lower right corner of the EEG wave sector. **Total Power** and the **Spectral Edge Frequency** are only displayed in the BIS® Task Window.

Components

The BIS® Module consists of the following major functional components:

Table 2-12 Major BIS® Module Components

Component	Description
Digital Signal Converter (DSC)	A sensor placed on the patient's head transmits EEG signals to the DSC. The DSC amplifies and digitizes signals from the sensor.
BIS® Engine	Filters the raw data from the DSC, analyzes it for artifact and processes data to calculate the BIS® index.
BIS® Module	Connects the BIS® Engine to the monitor

Theory of Operation

Bispectral analysis is a computational method, which examines the relationships or "coupling" among the frequency components of the EEG signal. Specifically, Bispectral analysis quantifies the level of synchronization in the EEG, along with the traditional amplitude and frequency parameters. Aspect Medical Systems has reduced the complex data arrays generated from Bispectral analysis using a sophisticated algorithm to generate a composite, numerical Bispectral Index® which tracks changes in the cerebral state.

Therefore Bispectral analysis determines the components of the EEG that are due to harmonic and phase relationships, and thus can provide more information regarding interactions between cortical and subcortical neural generators. These bicoherence patterns in the EEG have been found to change with increasing amounts of hypnotical drugs.

The Bispectral Index® is computed real-time using a combination of three analysis steps:

- The first step is an EEG preprocessor, which breaks the EEG signal down - second by second - and marks those segments containing artifact that might arise from movement, EMG or electrocautery equipment. Segments of suppressed EEG are also identified. These segments are excluded from further processing.
- The second step is the calculation of the hypnosis/sedation index by combining selected EEG features using the algorithm, which was developed as previously described.
- In the third step, the hypnosis sedation index is modified to better reflect the level of suppression in the EEG. The suppression ratio (SR) is computed as the percentage of suppressed EEG in the non-artifact data.

BIS Module Features

Figure 2-27 shows the user controls and connector for the BIS® Module. The parts are described following the figure.

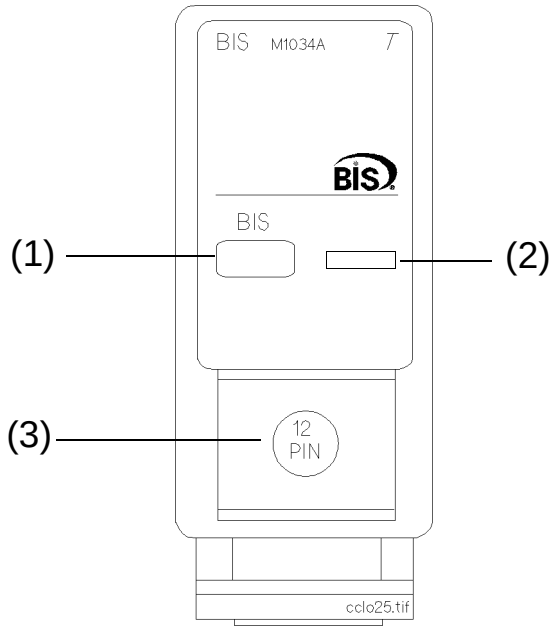


Figure 2-27 BIS® Module controls and connectors

User Controls

1 **Setup Key**: This is a single-press key, used to enter the BIS® setup screen.

2 **Setup Indicator**: This is a green LED, which will be lit when in the BIS® setup screen.

Connectors

3 The BIS® M1034A uses a **12-pin connector** for use with the BIS® Module Cable and the subsequent components.

Safety

To ensure the safety of the patient, the patient applied parts are isolated from ground by optical isolators and a transformer. In addition, all components are encapsulated in plastic.

This module complies with UL544, CSA No. 125-M1984 (for use with model M1165/66/75/76) and UL2601-1, CAN/CSA-C22.2 No.601.1-M90 (for use with model M1167/77), IEC-601-1, IEC-601-2-26. Patient leakage current is less than 10µA at 120V/60Hz.

It has an isolated patient connection to Class I protection, Type Body Floating (BF).

There is also protection against damage from defibrillation and electro surgery.

Chapter 3 CMS Patient Monitoring System

Introduction

This chapter is organized into four sections. Each section contains its own introduction, objectives and topics list.

This chapter covers the CMS, Philips' comprehensive, modular system for monitoring the entire range of a patient's clinical data. The CMS contains the superset of functions for the products in its family. The V24 and V26 offer many but not all of these functions and is described in chapter 4.

The CMS is also available in an Anesthesia specific model and a Neonatal specific model; for Anesthesia, the Anesthesia CMS (ACMS), and for Neonatal, the Neonatal CMS (NCMS). The components and parameter modules of the ACMS and NCMS are the same as those found in the Standard CMS with the exception of the Anesthesia Gas Module, which is an Anesthesia specific module.

This chapter presents an overview of the CMS/ACMS/NCMS, describes the modules it contains, and provides details on the individual function cards that carry out its operations. Important concepts are previewed at the beginning of each section. Exercises on the content of each section are included at the end of the first two sections and after each of the function cards.

Goals

After successfully completing this chapter, you should be able to:

- Describe the system's features
- Describe the system's functions
- Identify the system's components

Objectives

Each section of the chapter contains specific objectives that are focused on enabling you to meet these goals.

Topics

This chapter contains the following sections.

Table 3-1 Chapter Topics

Topic	Page
"CMS Patient Monitoring System Overview"	3-4
"CMS Patient Monitoring System Description"	3-6
"CMS Patient Monitoring System Modules"	3-8
"CMS Patient Monitoring System Bus Structure"	3-10
"CMS Patient Monitoring System Power System"	3-17
"CMS Patient Monitoring System Hardware Configurations"	3-19
"CMS Patient Monitoring System Software Configurations"	3-31

Table 3-1 Chapter Topics

Topic	Page
"CMS Patient Monitoring System Functional Modules"	3-34
"Computer Module"	3-35
"Remote Power Supply (M1047A)"	3-41
"Display Module"	3-43
"Remote Keypad"	3-54
"Module Racks"	3-55
"Plug-in Parameter Modules"	3-58
"CMS Master Function Cards"	3-63
"Master Card Overview"	3-64
"Application CPU"	3-69
"Configurable Processor Card"	3-74
"Monochrome Display Controller"	3-78
"Color Display Controller Cards"	3-81
"Color Display Controller Card (New Version)"	3-84
"Flatscreen Display Controller Card"	3-87
"DSPC_FLAT_ASIA Flatscreen Controller Card"	3-89
"Utility CPU"	3-92
"RS232/RS422 Dual Interface Card"	3-98
"HDLC Interface Card"	3-102
"Analog Interface Card"	3-105
"CMS Local Function Cards"	3-110
"Local Card Overview"	3-111
"EPROM"	3-113
"SRAM"	3-115
"Color Display Video Card"	3-118
"Serial Distribution Network Interface"	3-122
"Rack Interface"	3-126
"Aux Connector Card"	3-129
"Remote Switch Card"	3-129

Definitions

Concepts important to the Philips patient monitoring system:

- **CMS -** CMS Patient Monitoring System Models 54 through 68. These models are the bedside monitors with full displays for the critical care environment.
- **ACMS -** Anesthesia CMS Patient Monitoring System Models 74 through 88. These models are the anesthesia monitors with full displays for the operating room.

- **NCMS** - Neonatal CMS Patient Monitoring System Model 36 through Model 48. These models are the neonatal monitors with customized displays and parameter combinations for the Neonatal Intensive care unit.
- **V24/V26 -** This model is a bedside monitor with an LCD display for most critical and acute patient care areas of a hospital.
- **patient monitoring system -** A system that measures various aspects of a patient's medical condition.
- **SDN -** Serial Distribution Network. A monitoring network that allows monitors to display their patient information and data at other monitors on the network.

CMS Patient Monitoring System Overview

Introduction

This section of the chapter provides an overview of the CMS, including its hardware and software components. Subsequent sections go into more detail on the individual parts of the system.

Objectives

After successfully completing this section, you should be able to:

- Describe the purpose of the CMS and the clinical settings in which it can be used.
- Describe its significant features and capabilities.
- Identify its major components and their functions.
- Describe its bus architecture and power system.
- Identify its possible hardware configurations.
- Describe its software operating levels and displays.

Concepts

The following concepts are explained in this section of the chapter.

- The CMS is a fully modular computer system dedicated to acquiring and processing patient physiologic data. It is used in a range of clinical settings for all types of patients. A comprehensive set of patient parameters can be measured by this one system. The system can also connect to external monitoring devices for data integration. The system's modules can be easily configured and expanded to match the specific needs of clinicians and patients.
- The system consists of four types of modules: the Computer Module, Display Module, Module Rack, and Plug-in Parameter Modules. The Computer Module contains the function cards for the system and is responsible for distributing the power, data, and clocks throughout the system. The Display Module provides the power and the human interface for the system and, for the CRT version of the Display as well. The Module Racks are the interface between the monitor and the measurement parameter units. The Plug-In Parameter Modules provide the measurements and the patient interface.
- The Computer Module contains a backplane with three distinct buses. The Message Passing Bus distributes data and control signals among the processing cards on the backplane. The Local Bus groups the function cards into clusters and connects processor cards with their supporting cards. The Utility Bus distributes the power and clock signals through the system. The backplane has 24 slots for a variety of function cards of two types: processor cards, called master cards, and supporting cards, called local cards.
- Power for the CMS is provided by the Display and Computer Modules or, in some combinations with the Flatscreen display, the Remote Power Supply. The power supply in the Display Module or the Remote Power Supply connects to the facility's main power source and generates 60V DC for the system's use. Within the Computer Module, the DC-to-DC converter generates the voltages needed by the function cards; those voltages are distributed to the cards by the Utility Bus.

On power-up, the CPU first initiates diagnostics and then executes the application software.

- Several models and software releases for CMS are in use as of this writing. The configuration of the model determines which CPU and function cards it uses, as well as the card placement on the backplane. Two types of CPU are in use: Application CPU cards, which are either 10 or 15 MHz, and Configurable Processor Cards (CPCs), which are 40 MHz. Application CPU cards require separate memory cards; CPCs contain their own memory arrays.

Topics

This section contains the following topics.

Table 3-2 Topics in this Section

Topic	Page
“CMS Patient Monitoring System Description”	3-6
“CMS Patient Monitoring System Modules”	3-8
“CMS Patient Monitoring System Bus Structure”	3-10
“CMS Patient Monitoring System Power System”	3-17
“CMS Patient Monitoring System Hardware Configurations”	3-19
“CMS Patient Monitoring System Software Configurations”	3-31

CMS Patient Monitoring System Description

Introduction

The CMS is a modular patient monitoring system that can: (1) receive patient management data and physiologic measurements, (2) process the data in a variety of ways, and (3) display the results in multiple formats.

The CMS is designed to be used in a wide range of clinical settings, from nursing stations to critical care units. Its power and flexibility enable it to accommodate everything from basic monitoring requirements to complex and highly specialized applications.

The system's modular nature splits all major patient monitoring functions into individual modules that can be added as needed, interchanged between systems, and serviced as required. This modularity enables clinicians to put together systems to suit both the physical layouts of their units and the special needs of individual patients.

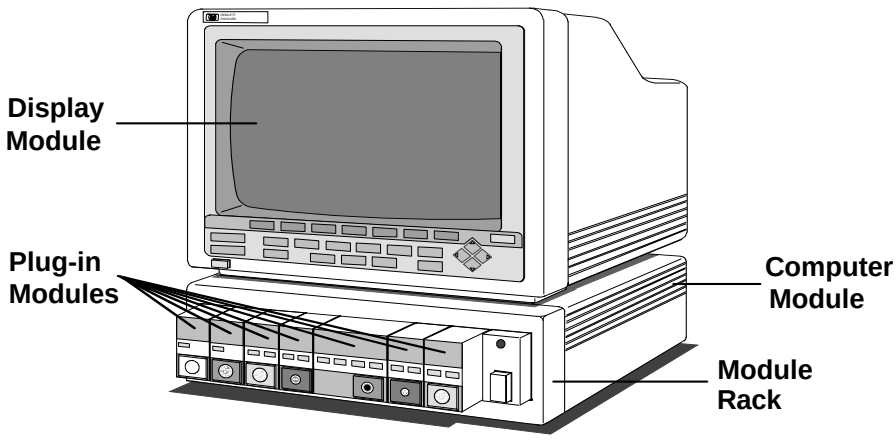


Figure 3-1 Philips CMS

CMS Functionality

The CMS is connected to the patient by means of electrodes, probes, transducers, or pressure catheters. The accessories attached to the patient are connected to individual modules that take specific measurements.

The system is switched on by pressing the On/Off switch on the front of the Main Display Module. After approximately 20 seconds, a display is shown on the screen. The number of waveforms displayed depends on the model of the system and how it is configured. Alongside each waveform, a corresponding numeric value for a measured parameter is also displayed.

The patient's vital signs are shown on the screen. The screen is set up according to either the default settings stored in the module or those settings made during installation. Changes can be made to the screen display or to the parameter settings. Alarms are set to on by pressing the Suspend key, which enables the system to announce alarms as it monitors the patient.

CMS Features

The CMS has a wealth of features that make it flexible, powerful, and easy to use. It provides a comprehensive set of patient measurements for use in a broad spectrum of clinical applications.

Some modules can be transferred from one system to another without losing their parameter settings. The VueLink module allows vital sign measurements to be imported from other monitors and auxiliary devices for correlation with other patient data.

The system offers networking and database management capabilities, as well as several useful analyses, calculations, and presentation capabilities, such as a drug calculator and an oxycardiorespirogram. It comes with a set of default configurations for four different patient care categories, and it has online help. Its open architecture enables it to use a number of standard interfaces to connect to external devices, and also allows for easy upgrades.

CMS Functions

Among the functions that the CMS can perform are the following.

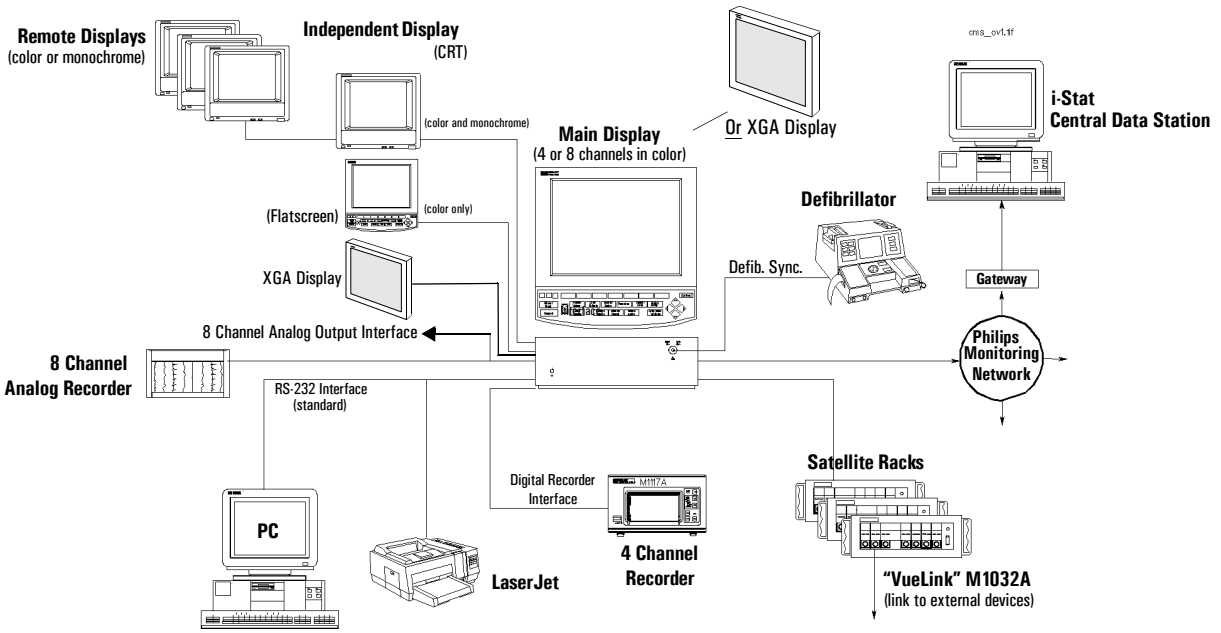
- Retrieve and display physiologic signals, such as ECG waveforms.
- Determine numeric values, such as heart rate.
- Check values against user-programmable limits and generate alarms.
- Detect life threatening events, such as apnea.
- Collect, store, and retrieve long-term data to provide trends of patient data.
- Communicate patient information to the Serial Distribution Network (SDN) and to printers.

CMS Patient Monitoring System Modules

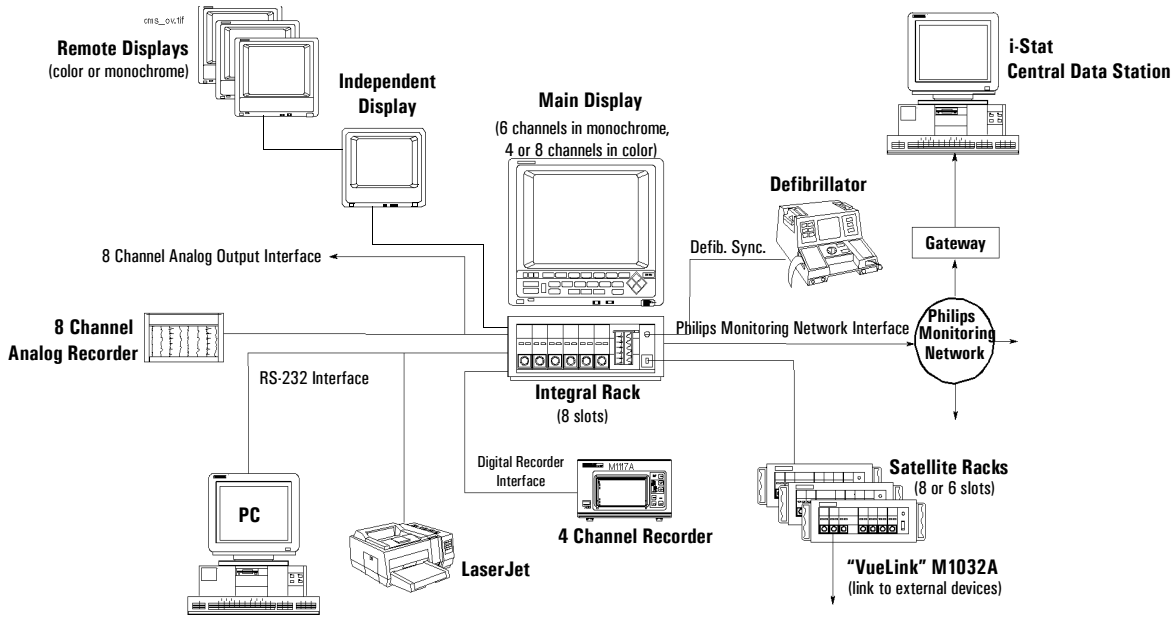
The CMS is made up of individual modules that can either be assembled together in the same location or positioned apart from each other in different locations. The components are as follows.

- **Computer Module -** contains all of the function cards. The front of the unit may contain a module rack or a cover piece for the module rack opening. The computer module also consists of the mechanical covers, guides, and backplane (bus). The function of this module is to process the data and to distribute the power, data, and clocks to the appropriate locations in the system.
- Display Module(s) - used to display patient data. The main display for the system is either a 14-inch CRT display monitor, monochrome or color, or a 10.4-inch Flatscreen LCD color display. Up to two independent displays, controlled from the main display, can be set up. Remote (or slave) displays can also be used; these are either 14- or 20-inch color or monochrome units. The main display contains an integral keypad called the Control Panel. An optional remote keypad is also available.

  Flatscreen Display Setup
  The setup requirements for the Flatscreen are different from those of the CRT Display Modules since no power supply is integrated into the flatscreen assembly. Possible setups for the Flatscreen are as follows:
  Flatscreen as Main Display - either a separate power supply or an integral power supply in the M1046B computer Module provides power for the system including up to two Flatscreens.
  Flatscreen as Independent Display - when the Main Display is a CRT display, this module can provide power for one Flatscreen independent display.
  The Flatscreen does not support any Remote (slave) displays.
- **Module Rack(s)** - used to hold the parameter modules. The rack(s) can be integral (connected to the front of the computer module) or external (for locating away from the monitor). If the rack is external, it is called a satellite rack.
- **Plug-in Parameter Modules** - used to acquire and process the patient data. Each module is dedicated to a specific set of measurements or functions. These modules are placed in the module racks. Most use accessories to attach to patients. A few, such as the Recorder, VueLink, and Data Transfer modules, have no patient connections



M1167A/77A
Philips CMS Patient Monitoring System (Flatscreen or XGA) System Overview



M1165A/66A/75A/76A
Philips CMS Patient Monitoring System (CRT) System Overview

Figure 3-2 Philips CMS Components

CMS Patient Monitoring System Bus Structure

Introduction

The bus structure of the CMS includes three distinct signal buses: a Message Passing Bus, a Local Bus, and a Utility Bus. The overall structure of the CMS is shown in Figure 3-3.

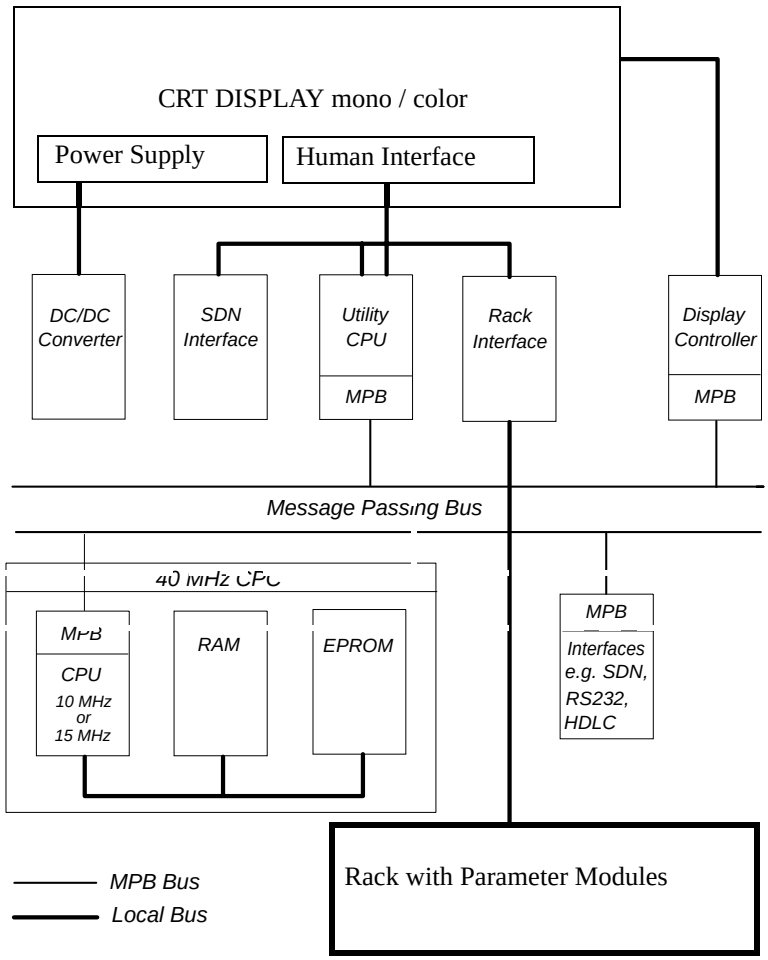


Figure 3-3 Philips CMS Bus Structure

Physical Backplane

The backplane of the computer module contains the buses used to interconnect the pieces of the CMS system. This backplane is made up of 24 connectors; 23 are for various function cards; one is dedicated to the DC-to-DC converter.

The connectors are mounted on both sides of the backplane, dividing the computer module into two halves.

The function cards are plugged into the connectors located either in the front of the computer module (2-24 even-numbered connectors) or the rear (1-21 odd-numbered connectors).

Message Passing Bus

The Message Passing Bus (MPB) is used to pass data among the processors in the system. The processors are located in the CPU cards and the interface cards, such as the RS232 Interface. These data are passed as messages.

Functionally, the MPB transfers data, performs arbitration to determine the next bus owner, and provides control signals.

Data Transfers

Data are transferred as a message on the MPB. Addresses are not used on this bus because data are not sent to a specific card; rather, it is broadcast to all cards on the bus. In addition, it is not necessary that a card know where the data have originated from because any required information is in the message.

The message contains a one word header describing the type of data (for example, ECG lead 1) and the length. Other cards on the bus read the header and determine whether they require the data.

Arbitration is necessary because there is more than one participant on the bus.

Local Bus

The Local Bus is used to connect a processor card, such as a CPU, with its supporting card or cards, such as a memory card. The functions of the Local Bus are to provide data transfers, addressing, and controls for data and address cycles.

Addressing

The Local Bus is capable of accessing specific addresses in memory. The memory is contained on cards such as Static Random Access Memory (SRAM) or Erasable Programmable Read Only Memory (EPROM).

Utility Bus

The Utility Bus distributes the power and clock signals for the system.

System Power

The power is placed on the bus by the DC-to-DC converter, which produces the required voltages from the Display Module's 60V DC output. The following voltages are placed on the Utility bus.

Table 3-3 Utility Bus Voltages

Voltage	Origin
+12V	Power Supply (from the DC-to-DC converter).
-12V	Power Supply (from the DC-to-DC converter).
+5V	Power Supply (from the DC-to-DC converter).
+60V	Power Supply (from the display module or separate power supply via the DC-to-DC converter).

System Timing

The clock signals are placed on the bus by the Utility CPU and are used to clock the rate of data acquisition. The clock used are as follows.

Table 3-4 Clocks on the Utility Bus

Clock Speed	Type of Clock
20MHz	System Clock (from the Utility CPU).
32ms	Frame Clock (C32MS) (from the Utility CPU).
2ms	Sample Clock (C02MS) (from the Utility CPU).

The system clock is derived from an IC on the Utility CPU. If power is lost, this chip is powered by a special capacitor. In a worst case scenario, the capacitor can supply power for at least 100 hours. In a typical scenario, the capacitor would supply power for at least 255 hours, or approximately 11 days.

Function Card Description Summary

Table 3-5 Function Card Summary

Component	Description
DC/DC Converter	Provides the voltages for the system.
Application CPU	One of the CPU types responsible for processing the data.
Configurable Processor Card	One of the CPU types responsible for processing the data.
DSPC Card	Outputs display data to the monochrome display.
CDSPC Cards	Outputs display data to the color displays.
Utility CPU	Provides interfacing to several devices.

Table 3-5 Function Card Summary

Component	Description
RS232/RS422 Dual Interface Card	Provides the CMS with an interface to the outside world.
EPROM Card	Stores the executable code and/or language dependent characters.
SRAM Card	Stores data before and after processing.
SDN Interface Card	Interfaces the CMS to the Serial Distribution Network.
Rack Interface Card	Interfaces the CMS with the module racks.
HDLC Interface Card	Interfaces the CMS with real time recorders using STRIP.
Analog Interface Card	Provides eight channels of analog output which can be connected to data collection instruments.
Remote Switch Card (M1046B only)	Provides connection and the remote switching of the DC power to the computer module, the module racks and the flatscreen display.
Aux Connector Card (M1046B only)	Provides access to the Rack Interface behind the Computer Modules integral power supply.

Function Cards

The function cards that reside on the backplane are grouped into two basic types: master cards and local cards. Master cards, which perform processing functions, connect to the MPB Bus; they may also connect to the Local Bus. Local cards connect to only the local bus.

Local Clusters

The backplane is divided into ten clusters to accommodate groupings of specific function cards. Each slot in the backplane belongs to a local cluster. Each cluster has its own dedicated portion of the local bus for connecting the cards in that cluster.

Clusters have between one and five card slots with predefined slot numbers. A cluster contains one master card and zero to four local cards, depending on the cluster. With the exception of the SDN Interface card, SRAM, and Rack IF card, more than one of each local card may be used on the backplane.

Figure 3-4 shows how the clusters are grouped on the backplane. Note that the DC-to-DC converter is located in a triple-sized gap on the rear of the backplane to the left of connector 21. The connectors within each cluster have the same color-coding for easy identification.

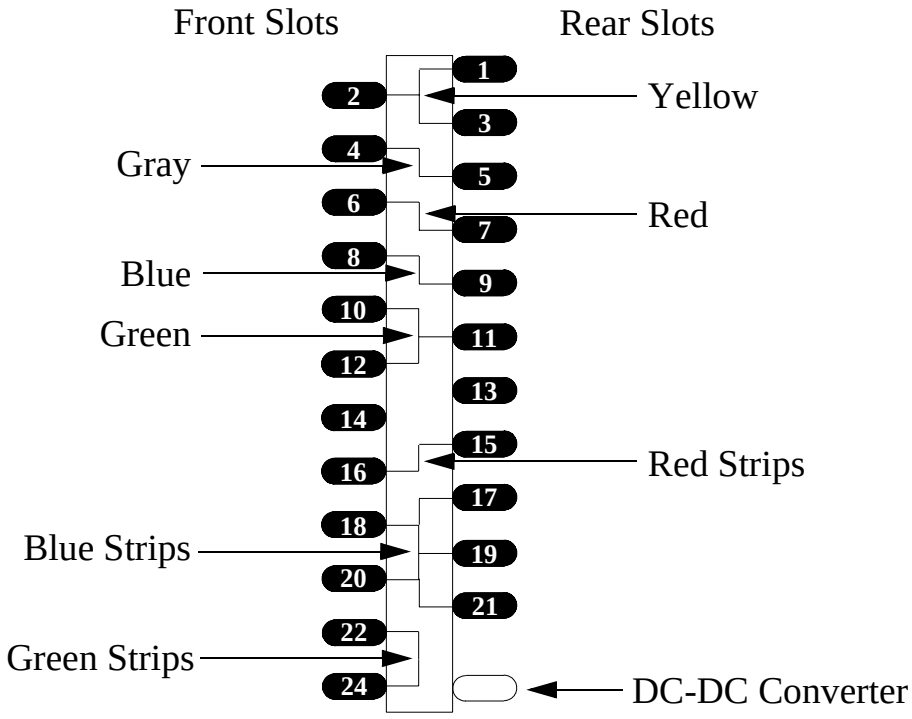


Figure 3-4 Backplane Configuration with Local Clusters

Card Placement

The rules associated with placement of the cards in the backplane are as follows.

- The DC-to-DC converter must be placed in the unnumbered slot (cluster 1).
- The Rack Interface card is placed in slot 18.
- If used, the DSPC_LANG card for Asian languages is placed in slot 3. (not required if the DSPC_FLAT_ASIA card is used in slot 1)
- Master cards can be used only once within any cluster.
- Local cards must be placed in the same cluster as their associated master card; they may be placed in any free slot within that cluster.
- Cards with external connections must be placed in the rear part of the backplane.
- The DSPC monochrome display controller has a connection to the local bus, although no local cards may be required for its operation. It must be located in the rear of the backplane for easy access.
- **M1046B only:** Aux Connector card must be placed in slot 24 and connected to the Rack Interface card.

- **M1046B only:** Remote Switch card must be placed in slot 8.

Table 3-6 Master Cards and their Associated Local Cards

Master Card	Associated Local Cards
Utility CPU	SDN Interface and Rack Interface
CDSPC-Control	CDSPC-Video
Application CPU	EPROM SRAM

Table 3-7 Rear Card Connections

Card	Connects to:
Utility CPU	HIL to the Monitor and Nurse Paging System
RS232 Interface	Printers or computer systems
SDN Interface	SDN network
HDLC Interface	M1117A Strip Recorder
Analog Interface	Analog device
CDSPC-Video	Color monitor
DSPC	Monochrome monitor
DSPC_FLAT	LCD monitor and Remote Switch to Remote Power Supply

Table 3-8 Display Interface and Slot Location

Type of interface	Slot Location
Monochrome	DSPC #1 in slot 1, DSPC #2 in slot 7
Color	CDSPC_CTRL #1 in slot 2 CDSPC_CTRL #2 in slot 6
	CDSPC_VIDEO #1 in slot 1 CDSPC_VIDEO #2 in slot 7

Minimum System Requirements

The minimum card requirements to start-up the system are defined in Table 3-8

Table 3-9 Required Cards for System Start-up

System	Required Cards
Systems with 10MHz and/or 15MHz Application CPU's in Backplane	All Application CPU cards (3,4, or 5 cards, depending on CMS model and CPU type)
	A display controller card
	EPROM MASTER and EPROM SLAVE
	SRAM
	Utility CPU
	Rack Interface Card
	M1046B only: Aux Connector Card
	M1046B only: Remote Switch Card
Systems with 40MHz CPC or combined 40MHz CPC and 15MHz APP_CPU in Backplane	CPC Card
	Application CPU card(s) (depending on CMS model)
	A display controller card
	Utility CPU
	Rack Interface
	M1046B only: Aux Connector Card
	M1046B only: Remote Switch Card

CMS Patient Monitoring System Power System

Introduction

The power system in the CMS uses the facility's AC source voltage and converts this AC line voltage to the DC voltages required for the CMS computer module and the various plug-in modules.

Components

The components in the power system network and their functions are as follows.

Table 3-10 Power Systems & Distribution Components and Functions

Component	Function
Power Cord	Used to plug into the main power source.
Source Voltage	Source voltage is from 92 to 262V AC. The voltage is self-selected.
DC-to-DC converter	Generates the voltages (+5,+12, and -12V DC) for the cards located in the computer module.
Display Module Switch-Mode Power Supply, Remote Power Supply, or Integral Power Supply in the M1046B Computer Module	Generates the 60V DC input to the DC-to-DC converter.
Utility Bus	Used to distribute the voltages (+5, +12, -12, and +60V DC).
CPU	Performs a hardware test, identifies the cards in the cluster, and starts executing the application software.

Theory of Operation

The CMS system is connected to the facility source voltage with an AC power cord to the AC outlet. This AC cord is connected to a connector on the back of the Display Module, the Remote Power Supply, or the Integral Power Supply in the M1046B Computer Module.

Computer Module (M1046A)

When the power is turned on, the Display Module (or the Remote Power Supply) receives the 120V AC (depending on the source voltage) and converts this voltage to 60V DC. The 60V DC is output through a connector on the back of the display (or Remote Power Supply) and is fed to the computer module through the 15-pin connector of the DC-to-DC converter.

Computer Module (M1046B)

When the power is turned on, the Computer Module M1046B receives the 120V AC (depending on the source voltage) and converts this voltage to 60V DC. The 60V DC is output through a connector on the back of the Integral power supply to the Remote

Switch card in slot 8 of the Computer Module. This 60 V DC is routed internally to the DC-to-DC converter.

NOTE

As no connection is made to the 15-pin connector of the DC-to-DC converter, a shorting stub **MUST** be connected to it so that the system operates correctly.

DC-to-DC Converter

A delay of between one to two seconds occurs between the time that the 60V DC arrives at the input to the DC-to-DC converter and the time that the DC-to-DC converter outputs the regulated voltages. This delay is used to ensure that the SYSRES (system reset) and PFAIL (powerfail) signals are in the correct state.

If the condition is determined to be a power-up, the DC-to-DC converter outputs the converted voltages (+5, +12, and -12), along with the 60V DC input voltage, onto the Utility bus.

Power-Up and Diagnostics

Before the CMS system can be powered up, it must have a base configuration of cards, including an application processor card, a display controller, a Utility CPU, and a Rack Interface.

After the power-up is complete, the CPU performs a hardware test. After the hardware test is finished, the CPU locates and identifies the other cards in the cluster. This is done by sending out an address that identifies the slot(s), and an ACCESS signal that results in the local card placing an identifier onto the local bus.

If an EPROM card is connected, the CPU begins executing application software code from the EPROM card. If an EPROM card is not present, the CPU begins execution of the application software code from the CPCs flash EPROMS.

Note: Depending on the type of configuration, the CPU is either an APP_CPU or a CPC CPU. The APP_CPU is available as either a 10 or 15 MHz card. The CPC is 40 MHz. Both a CPC and a 15 MHz APP_CPU can be present on the backplane.

System Reset

If the CPU detects an error in the system, or the watchdog timer detects a failure on the CPU, the signal PFAIL is generated by the CPU and sent to the Utility CPU. The Utility CPU, in turn, generates the SYSRES signal, which resets all the cards in the computer module.

CMS Patient Monitoring System Hardware Configurations

Introduction

The CMS is available in different models, each configured differently. The monitor's configuration determines the CPU and function cards it can include, as well as their arrangement. The configuration of cards in the CMS depends on both the model of the system and the type of application CPU used.

Application CPUs

Several types of CPU cards are used in the system for processing application data:

- M1054 Application CPU, 10 MHz.
- M1051 Application CPU, 15 MHz.
- M1053 Configurable Processing Card (CPC), 40MHz.

CMS models delivered with Releases A or B software may use either 10 or 15 MHz Application CPUs. Models delivered with Release C software use only 15 MHz Application CPUs. However, models with 10 MHz cards that upgrade to Release C software use a combination of 10 and 15 MHz cards.

Releases C and subsequent software provide support for models with a CPC in slot 12. In these models, additional 15 MHz Application CPUs may be required, depending on the model, or may be left in for future use. Beginning with Rel. A.0 two 40 MHz CPC cards in slot 4 and 12 are required for all models.

Figure 3-5 through Figure 3-12 show the backplane configurations for these systems.

Memory

Application CPU cards use both EPROM and SRAM cards. Two types of SRAM card are available:

- M1055-66501 SRAM LO: standard for 10 and 15 MHz systems.
- M1056-66501 SRAM HI: used with option #CO3 in 10 and 15 MHz systems.

CPCs contain their own memory arrays, including four types of memory. Two versions of CPC are available: the M1053-66514 and M1053-66515. These CPCs are discussed in the Master Cards section of this document.
Models which use the CPC cards will not have EPROM and SRAM cards.

Function Card Placement

The function cards are interconnected by the backplane within the Computer Module. The function cards are mounted on both sides of the backplane and may be located either in the front of the Computer Module (even-numbered connectors) or the rear (odd-numbered connectors). The local clusters of the backplane are color-coded on the Computer Module, so that they can be easily identified. On the rear of the backplane, to the left of connector 21, there is a triple-sized gap. This is the only place where the dc-dc converter can be located.

The newer Computer Module (M1046B) has an integral power supply. As a result these Computer Modules have additional function cards.

Function Card Placement in the backplane of the monitor is dependent upon the following:

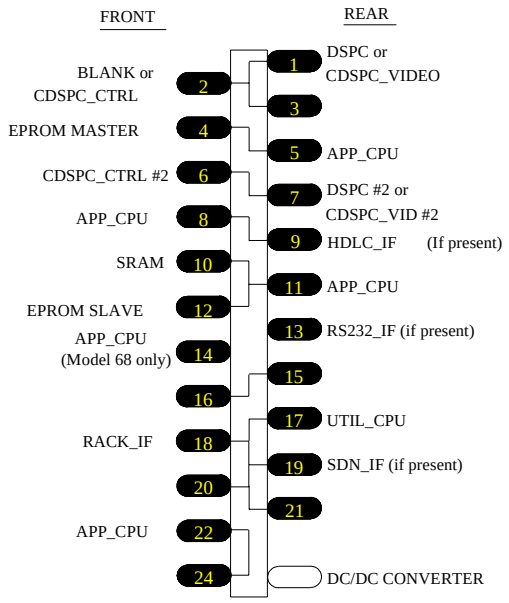
1. The monitor model ("(S)" indicates the non-US-models):
   - **CMS:** Models 54 (S), 56 (S), 64 (S), 66 (S), 68 (S)
   - **ACMS:** Models 74 (S), 76 (S), 84 (S), 86 (S), 88 (S)
   - **NCMS:** Models 36 (S), 44 (S), 46 (S), 48 (S)

2. Type of processor cards used
   - 10 MHz CPU cards M1054-66501
   - 15 MHz CPU cards M1051-66501
   - 40 MHz CPC card M1053-66515

3. Type and combination of display controllers used
   - M1066-66501 DSPC (Monochrome)
   - M1066-66531 DSPC (Monochrome)
   - M1066-66543 DSPC (Monochrome with integrated DSPC-lang)
   - M1072-66521 CDSPC-CTRL (Color) together with M1072-66501 CDSPC-VIDEO
   - M1072-66531 CDSPC (Color)
   - M1072-66543 (Color with integrated DSPC-lang)
   - M1074-66501 DSPC-FLAT (Flatscreen color)
   - M1074-66502 DSPC-FLAT (Flatscreen color)
   - M1074-66503 DSPC-FLAT (Flatscreen Color with integrated DSPC-lang)
   - M1075-66503 XGA DSPC (XGA with integrated DSPC-lang)

Software Release A
10 and 15 MHz
APP-CPUs

Using 10MHz Application CPUs



Using 15MHz Application CPUs

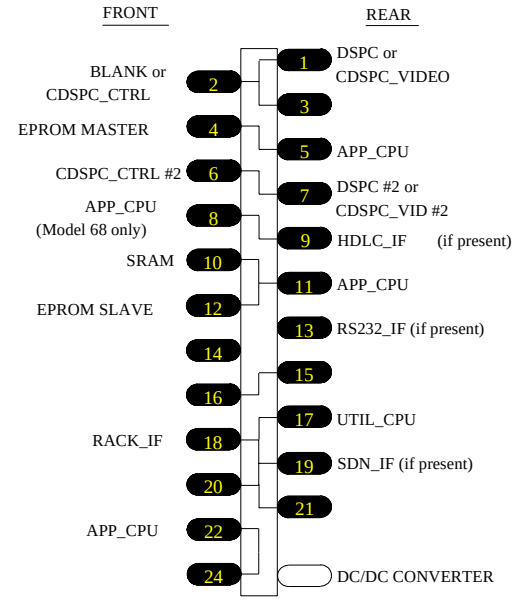
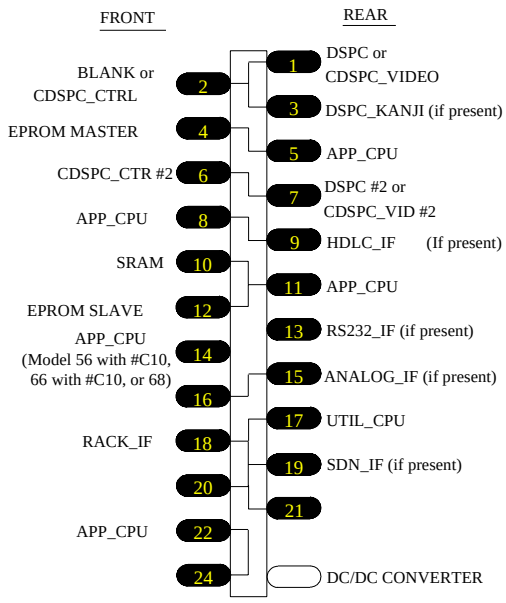


Figure 3-5 Software Release A Backplane Configuration

Software Release B
10 and 15 MHz
APP_CPUs

Using 10MHz Application CPUs



Using 15MHz Application CPUs

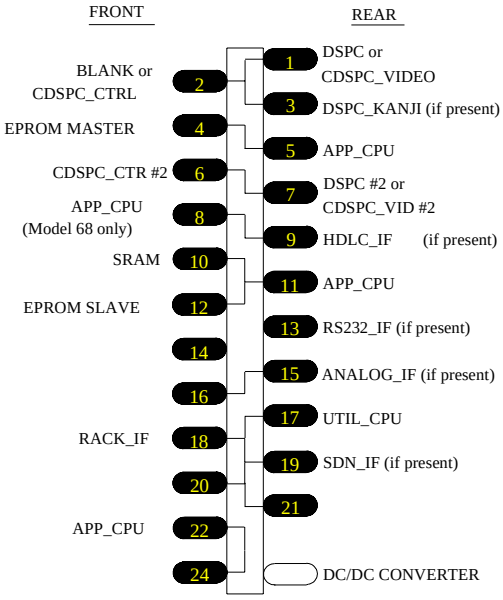
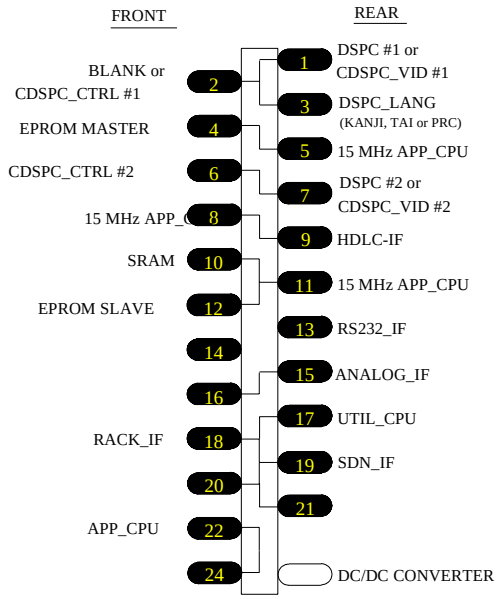


Figure 3-6 Software Release B Backplane Configuration

Software Upgrade, Release C, 10 MHz CPU

Models 54(S)/64(S) and Models 56(S)/66(S) without #C26



Models 56(S)/66(S) with #C26 and Model 68(S)

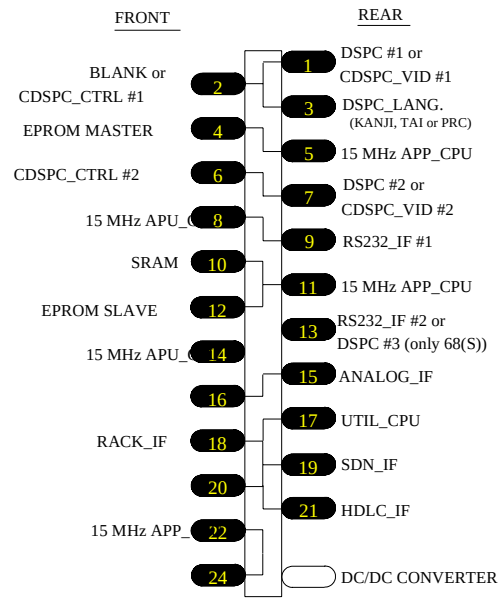


Figure 3-7 Software Release C Backplane Configuration (10MHz CPU)

Release C (without CPC) Upgrade Backplane

The table below shows the slot locations and quantity of 10 MHz (M1054-66501) and 15 MHz (M1051-66501) APP_CPUs for those CMS that have been upgraded from software release A or B with 10 MHz CPU's exclusively, to software release C *without* CPC.APP_CPU Slot Location and Quantity

A54S/A66S	5[1], 8, 11, 14, 22
A56S,/A66S	5[1], 8, 11, 14, 22
A56(S)/A66(S) (#C10)	5[1], 8, 11, 14, 16[2], 22
A56(S)/A66(S) (#C26)	5[1], 8, 11, 14, 16[1], 22

1 This is a 15 MHz CPU.

2 The systems that have been upgraded from software release B to software release C with existing C10 will contain a 10 MHz processor in slot 16. If C10 is added to a Software Release C monitor, there will not be a 10 MHz processor in slot 16.

Rel. C+ to Rel. G 15 MHz APP_CPU Requirements

Model	Slot 22	Slot 4
Standard CMS		
A68(S)	Required	Extra card
A56(S)/A66(S)	Required[1]	Extra card
A54(S)/A64(S)	Extra card	Extra card
Anesthesia CMS (from Rel. E$_{8}$)		
A88(S)	Required	Required
A76(S)/A86(S) (#C25)	Required	Required
A76(S)/A86(S) without (#C25)	Extra card	Extra card
A74(S)/A84(S) (#C24)	Required	Extra card
A74(S)/A84(S) w/o (#C24)	Extra card	Extra card
Neonatal CMS (from Rel. F)		
A36(S)/A46(S)/A48(S)	Required	Extra card

1. Not required in certain earlier releases.

Software Release C with CPC and Release D

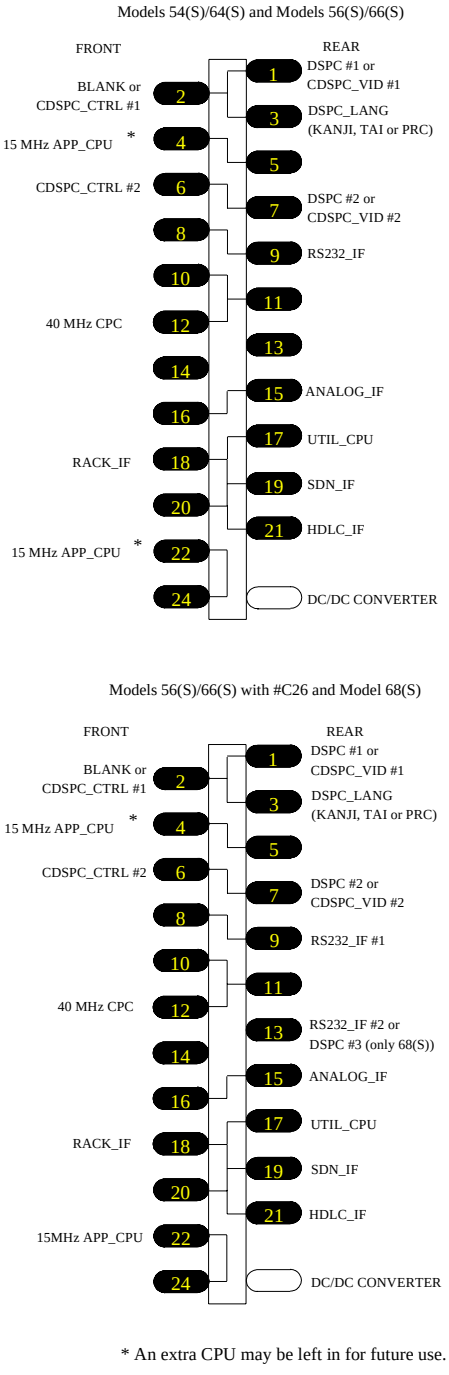


Figure 3-8 Software Release C and D Backplane Configuration

Software Release E or $E_ß$

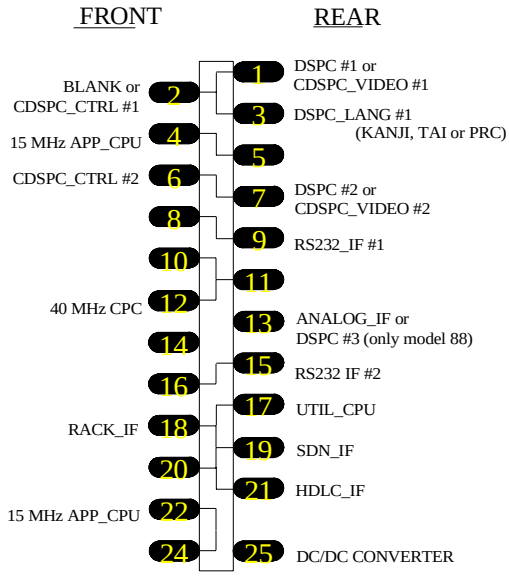
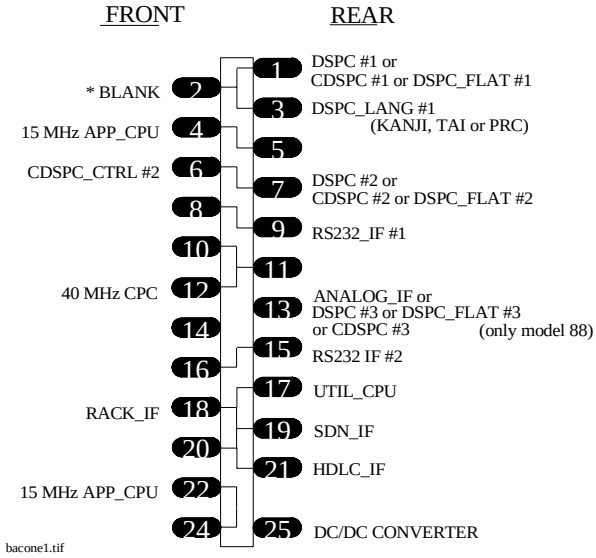


Figure 3-9 Software Release E or $E_ß$ Backplane Configuration

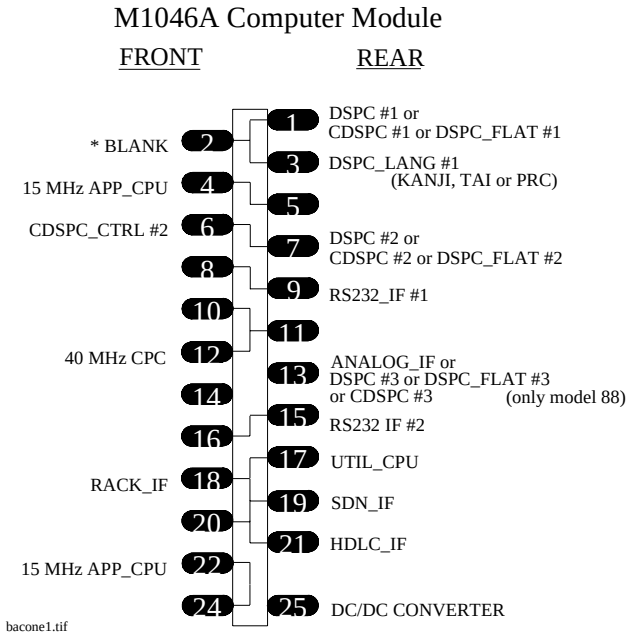
Software Release F



* If upgraded (to F) may still have CDSPC_CTRL #1.

Figure 3-10 Software Release F Backplane Configuration

Software Release G



* If upgraded (to G) may still have CDSPC_CTRL #1.

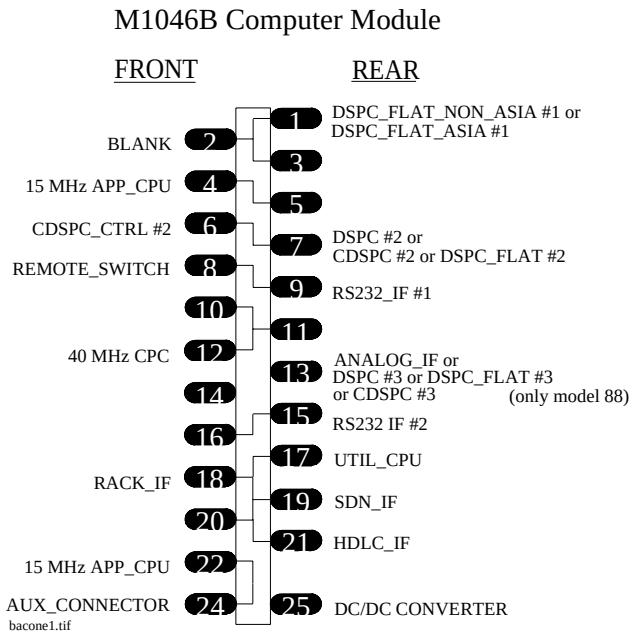
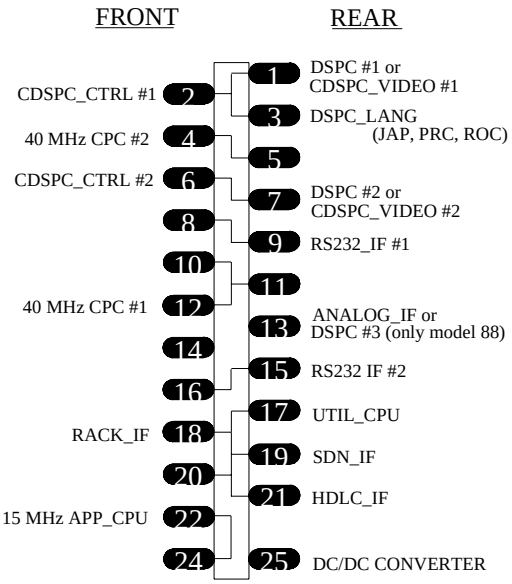


Figure 3-11 Software Release G Backplane Configuration

Software Releases
A.0 to C.0

M1046A Computer Module

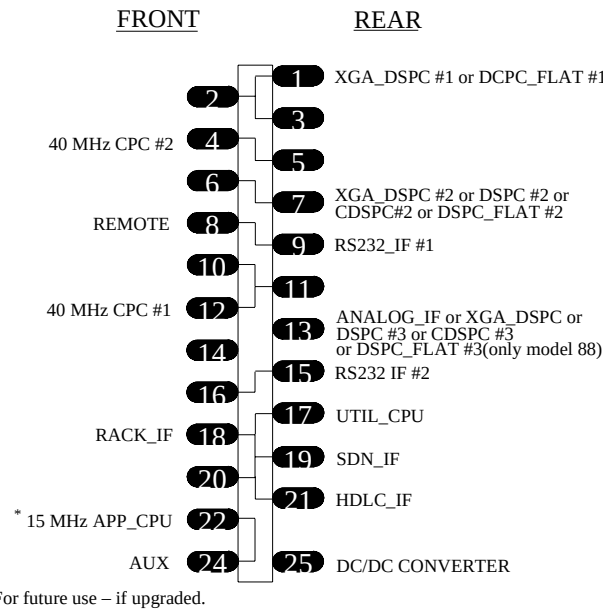
Systems with M1066-66501 (DSPC) or
M1072-66521 (CDSPC_CTRL) +
M1072-66501 (CDSPC_VIDEO)



* For future use – if upgraded.

M1046B Computer Module

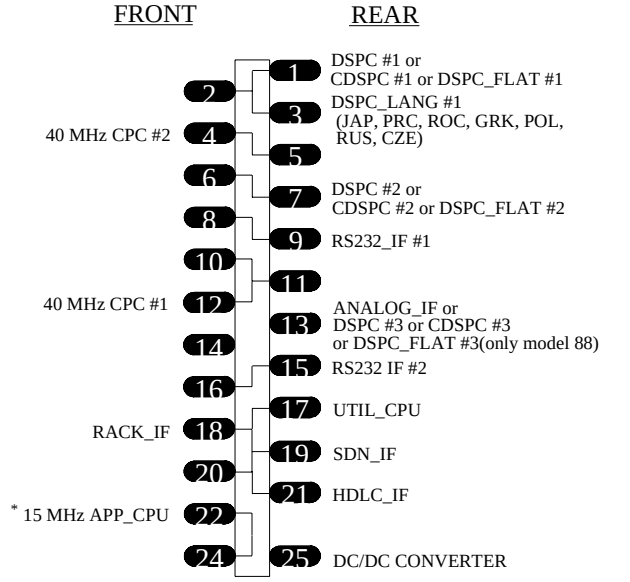
Systems with M1075-66503 (XGA_DSPC) or
M1074-66503 (DSPC_FLAT)



* For future use – if upgraded.

M1046A Computer Module

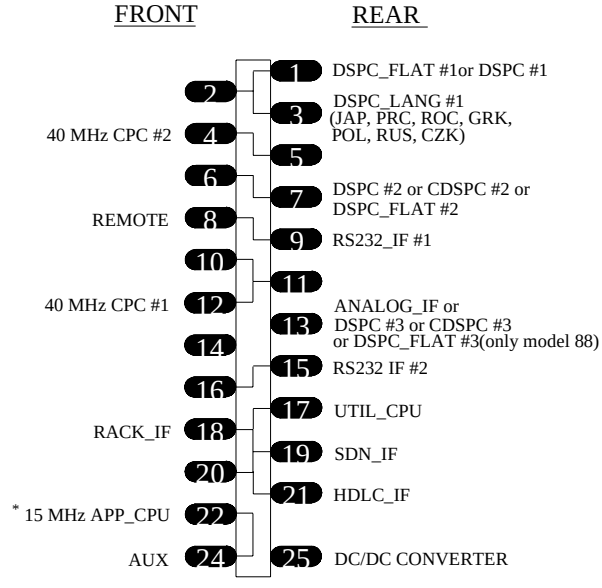
Systems with M1066-66531 or M1066-66643** (DSPC) or
M1072-66531 or M1072-66543** (CDSPC) or
M1074-66501 (DSPC_FLAT) or
M1074-66502 (DSPC_FLAT)**



*For future use – if upgraded ** with these controllers no DSPC_LANG is required

M1046B Computer Module

Systems with M1074-66501(DSPC_FLAT) or
M1074-66502 (DSPC_FLAT)



*For future use – if upgraded

Figure 3-12 Software Release A.0 to C.0 Backplane Configuration

Plug-in Parameter Modules

The number of Plug-in Parameter Modules that can be used with a system, depends on the model and software revision. Please refer to Appendix A “Product Information” in the *Philips CMS Patient Monitoring System Service Guide* for detailed information.

If too many modules are plugged in, a message is displayed in the system message field on the screen as follows:

Currently ignored module in rack position R-P

where:
R = the number of the rack (1 = internal, 2 = first satellite, and so on)
P = the slot number in that rack (1 = left-most slot, 8 = right-most slot)

The following message is displayed if an unknown module is plugged into the rack:

Unrecognized module in rack position R-P

CMS Patient Monitoring System Software Configurations

Introduction

The CMS display module shows one of three types of screen, depending on the level of operation taking place. The screens are: the Standard Display, the Selection Window, and the Task Window.

Standard Display

This display shows the parameter information that previously had been selected to be monitored. The information is displayed as waveforms and numeric readouts. In addition, alarms, INOP messages, bed labels, date and time, and arrhythmia messages (when assigned) are displayed.

The numeric values associated with each waveform are displayed with the waveform. Numeric information is updated every two seconds. If a color display is being used, the waveform and its associated parameter value are displayed in the same color.

Pressing the *Standard Display* key (or Main Screen in later versions) returns the display to Standard Display.

Selection Window

The selection window is used to select an activity or function. The window is entered by pressing one of the blue-labeled hardkeys on the control panel or the keypad.

When the selection window appears, the last line is highlighted, indicating that it is active. The highlight can be moved to a different row by using the arrow keys on the control panel or the handheld keypad (if they are highlighted), or by pressing the same hardkey that was used to open the window. Then, pressing the softkey associated with the desired function invokes the task window for that function.

Task Window

The task window is used to make changes to parameters or screen displays, or to perform functions. Each parameter or procedure has a task window.

The task window is entered either by using the selection window or by pressing the setup key on the module. Once in a task window, the softkeys can be used to select one of the options that appears at the bottom of the display.

Screen Messages

At any time, two types of message can appear on the display: prompt messages, which instruct the user to perform an action, or status messages, which give information about a current situation.

An example of a status message is as follows:

> sync output not available, plug-in ECG module

The previous message would be displayed as long as the ECG module was not plugged in. Depending on the operating level, the message would be displayed either in the appropriate Task window or at the top of the Standard Display screen.

System Overview Exercises

1. The types of patient data collected and processed by the CMS are _____ and _____ data.

2. Which CMS module uses integral or external keypads to accept user input?

   a. Computer Module
   b. Display Module
   c. Module Rack
   d. Plug-in Parameter Modules

3. Which bus transfers data and control signals among its users?

   a. Message Passing Bus
   b. Local Bus
   c. Utility Bus

4. Which bus connects master and local cards into clusters?

   a. Message Passing Bus
   b. Local Bus
   c. Utility Bus

5. Which component of the power system generates 60V DC from the facility's main power?

   a. Computer Module's DC-to-DC converter
   b. Computer Module's Utility Bus
   c. Computer Module's central processor
   d. Display Module's power supply

6. Which component of the power system distributes the required voltages to the monitor's other components?

   a. Computer Module's DC-to-DC converter
   b. Computer Module's Utility Bus
   c. Computer Module's central processor
   d. Display Module's power supply

7. Which component performs diagnostics when the system is powered up?

   a. Computer Module's DC-to-DC converter
   b. Computer Module's Utility Bus
   c. Computer Module's central processor
   d. Display Module's power supply

8. Which software releases support both 10 and 15 MHz CPU cards?

   a. Release A and B
   b. Release A, B, and C
   c. Release A, B, C, and D

9. Which processor contains its own memory array for the application software code?

   a. Configurable Processor Card
   b. Application CPU
   c. Utility CPU

10. Which of the following will get a user directly to the task window for performing a function?

   a. The Standard Display key
   b. A blue-labeled hardkey
   c. The plug-in module's setup key
   d. a and b
   e. b and c

Answers

1. physiologic, management

2. b

3. a

4. b

5. d

6. b

7. c

8. b

9. a

10. c

CMS Patient Monitoring System Functional Modules

Introduction

This section of the chapter covers the functional modules of the CMS in more depth. It includes details on the physical and functional components and operations for several of the modules.

Information on the components and operation of the Computer Module is covered in the two Functional Card sections of this document. Information on the components and operation of the Plug-in Parameter Modules is covered in Chapters 1 and 2.

Objectives

After successfully completing this section, you should be able to identify the:

- Purpose and functions of each major functional module of the CMS.
- Physical components, including controls and connectors.
- Functional components and operations of the Display Module.

Concepts

The following concepts are covered in this section of the chapter.

- **Computer Module**- This receives and processes data from the Plug-In Parameter Modules and sends it to the Display Module to be displayed as waveforms and numeric values. The front of the Computer Module can have either an integral module rack or a blank panel. The Computer Module contains connectors on the front for a rack and other external devices, such as defibrillators. The rear of the module contains connectors for power, ground, network, video, and several interfaces.
- **Display Module**- This provides the video display and, in the case of the CRT display, power for the CMS. Several models are available; displays may be the main displays, independent displays, or slave displays. Up to three slave displays may be connected. Main displays have a Control Panel on the front, but independent and slave displays do not. The number and type of controls and connectors depend upon whether a display is a main display or not. The Control Panel controls are used to display screens of data, respond to alarms, and access various functions of the system's software.
- **Module Rack**- This connects the Plug-In Parameter Modules to the Computer Module. The rack may be an integral rack, which is connected to the front of the Computer Module, or a satellite rack, which is connected remotely. An integral rack can support up to eight single-width plug-in modules and up to three satellite racks. A satellite rack can support either six or eight plug-in modules and one additional satellite rack. The integral rack also has a connector for defibrillator synchronization.
- **Plug-In Parameter Module**- Collects most of the patient data and processes patient measurements; three of the modules do not take measurements. Fourteen types of module are available. Some of them have transferable settings that are retained when the module is transferred from one rack to another. Each module has a connector on the back for the rack; most have front connectors for accessories that are connected to the patient.

Topics

This section contains the following topics.

Table 3-11 Topics in the Function Modules Section

Topic	Page
“Computer Module”	3-35
“Integral Power Supply - Computer Module (M1046B)”	3-40
“Remote Power Supply (M1047A)”	3-41
“Display Module”	3-43
“Remote Keypad”	3-54
“Module Racks”	3-55
“Plug-in Parameter Modules”	3-58

Computer Module

Introduction

The Computer Module is the heart of the CMS. It distributes all of the power, clocks, and data for the entire system. The Computer Module receives data on patient measurements from the Plug-In Parameter Modules, processes the data, and sends it to the Display Module to be displayed as waveforms and numeric values.

All of the functional cards for the CMS reside within the Computer Module, which manages their operations. For details on the bus architecture and configuration of the module, refer to CMS Bus Structure in the System Overview Section (“CMS Patient Monitoring System Bus Structure” on page 3-10). For details on the operations and of the function cards, see the Master Card section (“Master Card Overview” on page 3-64) and Local Card section (“Local Card Overview” on page 3-111) of this document.

Front of the Computer Module

The front of the Computer Module is shown in the following figure. The module can have an integral module rack at the front, where the plug-in modules are connected. If the module uses a satellite rack instead of an integral rack, the front panel is blank.

Front Connectors

The front of the Computer Module contains two function cards with connectors, the Rack Interface card connector in slot 18 and the CPC card connector in slot 12 in later releases. The Rack Interface connector is used to collect output for the Computer Module from the plug-in module rack (integral or blank) and the CPC Flash port is used by the CPC Programming Tool for programming functions. Most models contain a Sheet Metal Cover over the front function cards. The cover has two ports for access to the front connectors

.

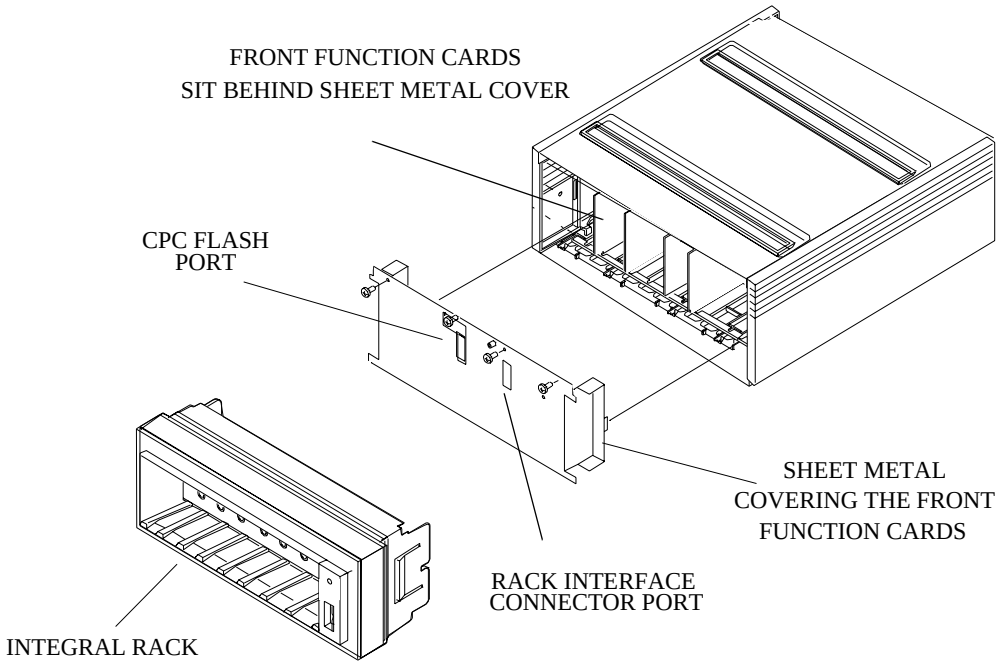


Figure 3-13 M1046A Computer Module Front Connectors

Front Connectors new Computer Modules (M1046B)

There are extra connectors on the front of the M1046B Computer Modules with an integral power supply.

Remote Switch

This connects the integral power supply to the backplane of the computer module and allows the flatscreen display to control the power for the Computer Module.

FE-Link & ECG sync

These connectors are found on the AUX_CONNECTOR card in slot 24 to allow access to the RACK_IF card in slot 18 behind the power supply. An ECG adapter allows you to connect to the ECG sync connector through a hole in the front plastic cover.

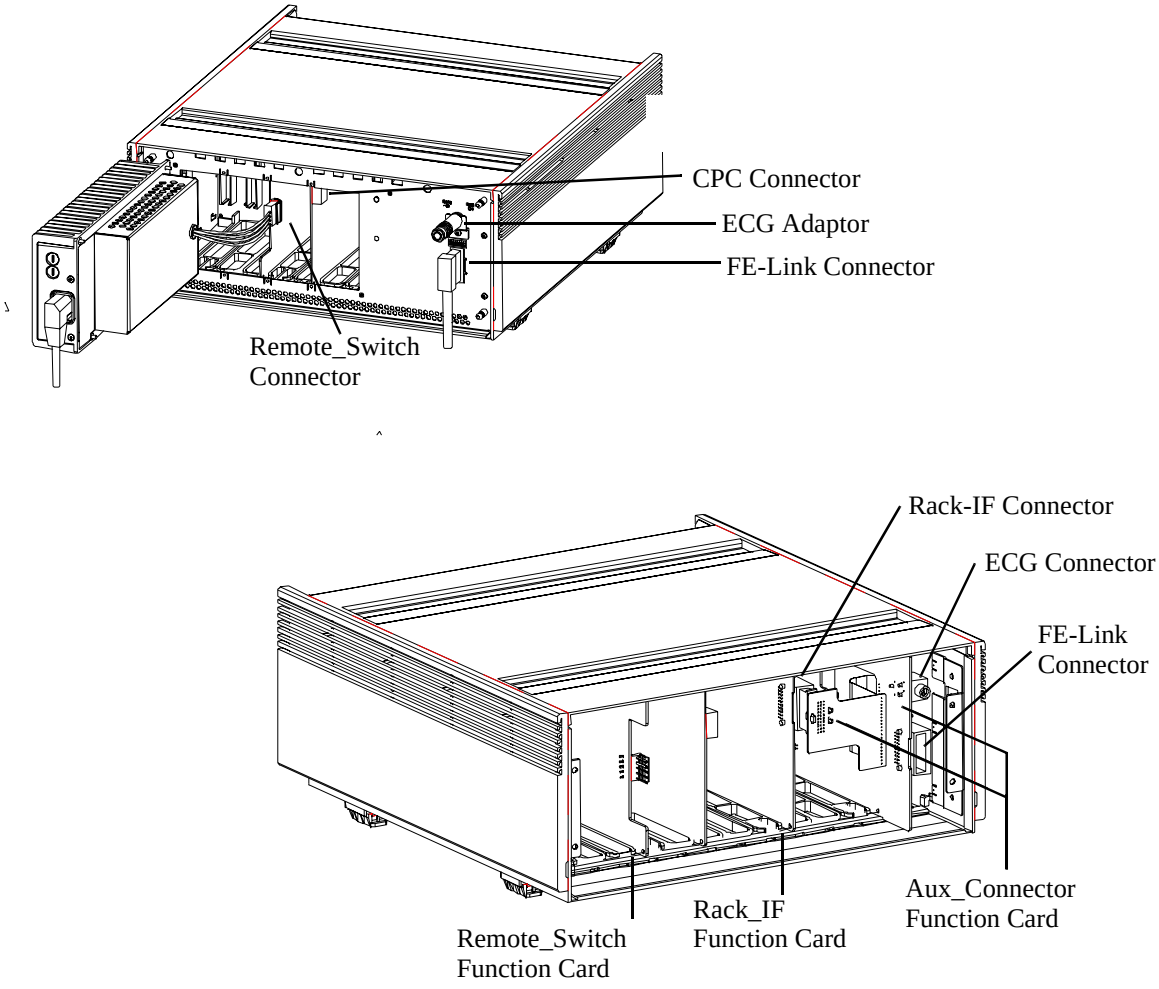


Figure 3-14 M1046B Computer Module Front Connectors

Rear Connectors

The rear panel of the Computer Module will have several connectors. The number and the type of connectors present is dependent upon which function cards are fitted in the Computer Module backplane. Any unused rear backplane function card slots are fitted with blank slot covers. A typical Computer Module rear panel is shown below.

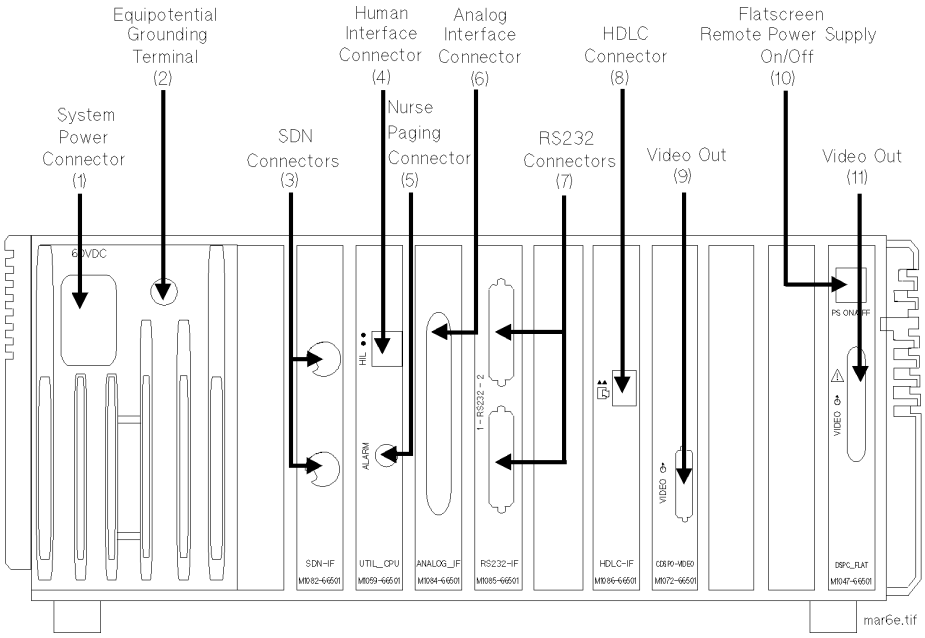


Table 3-12 Computer Module Rear Connectors

	Connector	Function
1	System Power Connector (DC/DC Convertor)	15-pin “D”-type connector, used to input the 60V dc from either a Main CRT Display Module or the Remote Power Supply Module if a flatscreen is used as the main display. **For M1046B:** The 60V dc is supplied from an integral power supply. A shorting stub **MUST** be installed in this connector or the system will not function correctly.
2	Equipotential Grounding Terminal	Used to connect the Computer Module to the hospital's grounding system.
3	SDN Connectors (SDN Interface)	Philips connectors, used to input/output information to/from a SDN network.
4	Human Interface Connector (Utility CPU)	Human Interface Link (HIL) connector, used to input the information from the Control Panel in the Main Display Module and the Remote Keypad.
5	Nurse Paging Relay output	Mini-phone jack, used to connect to the hospital's Nurse Paging System.
6	Analog Interface Connector	37-pin “D” type connector used to output information to analog devices.

Table 3-12 Computer Module Rear Connectors *(Continued)*

	Connector	Function
7	RS232 Connectors (RS232 Interface)	Two 25-pin “D” type connectors used to output information to a printer or computer systems. Only the upper connector (port 2) can be used to output RS232 information to printers.
8	HDLC Connector	Used to connect to a STRIP recorder, M1117A.
9	Video Out Connector (CDSPC-Video or DSPC)	9-pin “D” type connector, used to output information to be displayed on the Display Module.
10	PS ON/OFF connector (DSPC_Flat)	Used to control remotely the 60V DC output of the Remote Power Supply Module. **For M1046B** with an integrated power supply, this connector is not used.
11	Video Out Connector (Flatscreen)	Used to output information to be displayed on the Flatscreen Display Module and also to output 60V DC to the Flatscreen Display Module.

NOTE

No connection can be made to the following cards: Application CPU, CDSPC Control, EPROM, or SRAM.

Integral Power Supply - Computer Module (M1046B)

The M1046B Computer Modules use a flatscreen M1095A as the main display. The power supply previously located in either the main CRT display or the Remote Power Supply is replaced by an Integral Power Supply located in this Computer Module (M1046B).

Integral Power Supply - Connectors and Controls

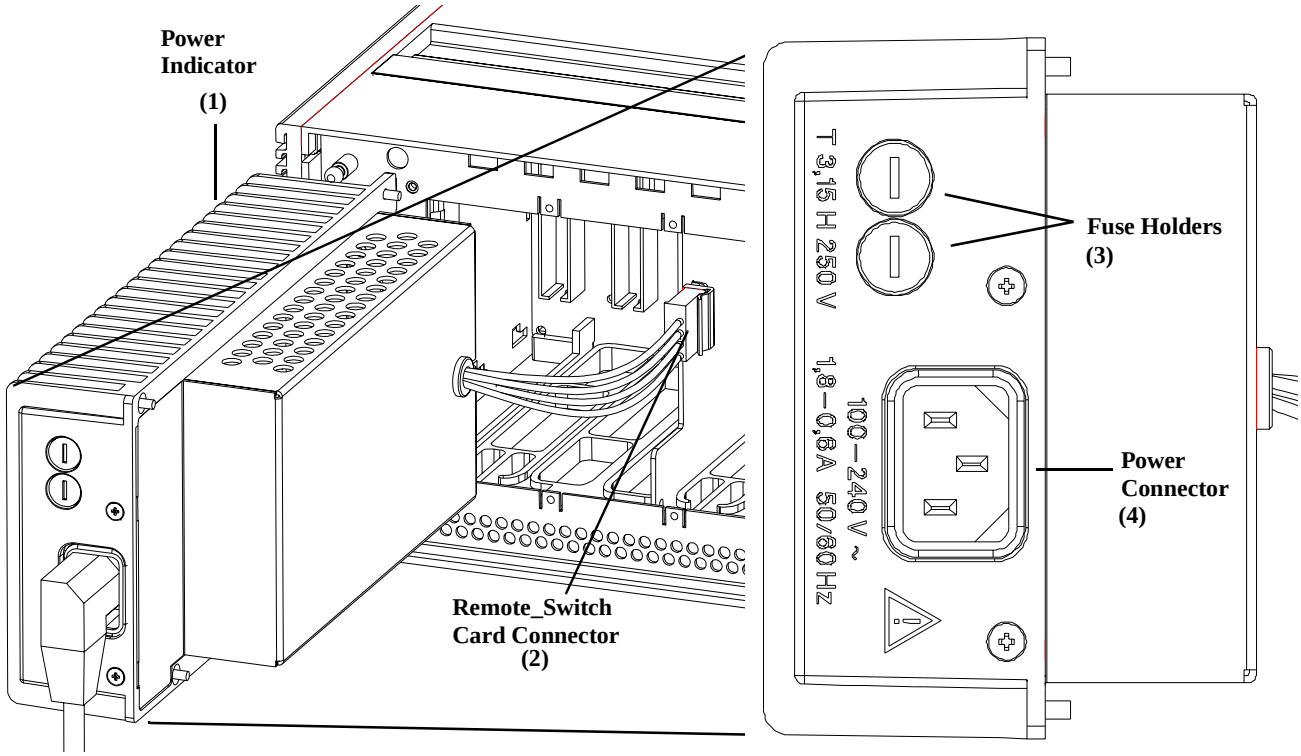


Figure 3-15 Integral Power Supply Connectors and Controls

Table 3-13 Integral Power Supply Controls and Connectors

	Controls and Connectors	Function
1	LED mains power indicator	This indicates that the Integral Power Supply is connected to the local power.
2	REMOTE_SWITCH card connector	This is a cable-end connector, used to connect the Integral Power Supply to the REMOTE_SWITCH card in the Computer Module.
3	Fuse Holders	Two fuse holders for the line protection fuses. (2 x 3.15 A H)
4	Local Power Connector	This is a 3-pin connector, used to input the local line voltage.

Remote Power Supply (M1047A)

The CMS can use the flatscreen M1095A as the main display instead of a CRT display. In this case, the power supply usually located in the main CRT display has to be replaced by a Remote Power Supply.

Front Panel Controls - Remote Power Supply

The controls on the front panel of the Remote Power Supply are shown below:

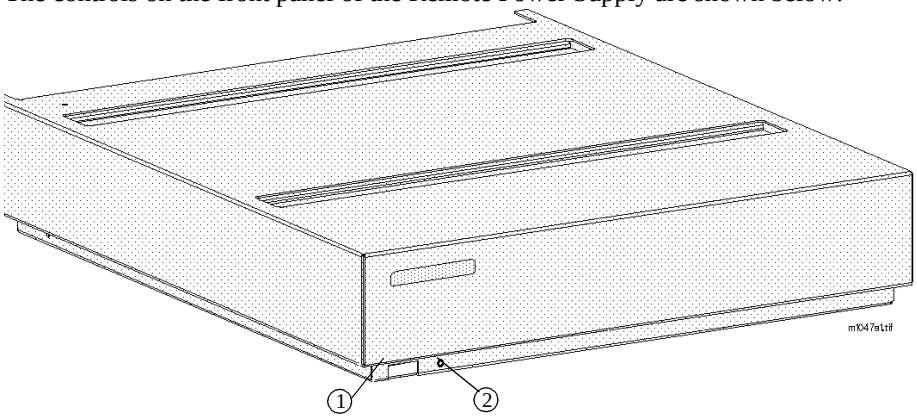


Figure 3-16 Remote Power Supply Front Panel

Table 3-14 Remote Power Supply Controls and Connectors

	Controls	Function
1	ON/OFF Switch	Used to turn the Remote Power Supply ON/OFF.
2	Power ON indicator	Green LED which is lit when the power supply is switched ON.

Remote Power Supply - Rear Controls and Connectors

The controls on the rear panel of the Remote Power Supply are shown below:

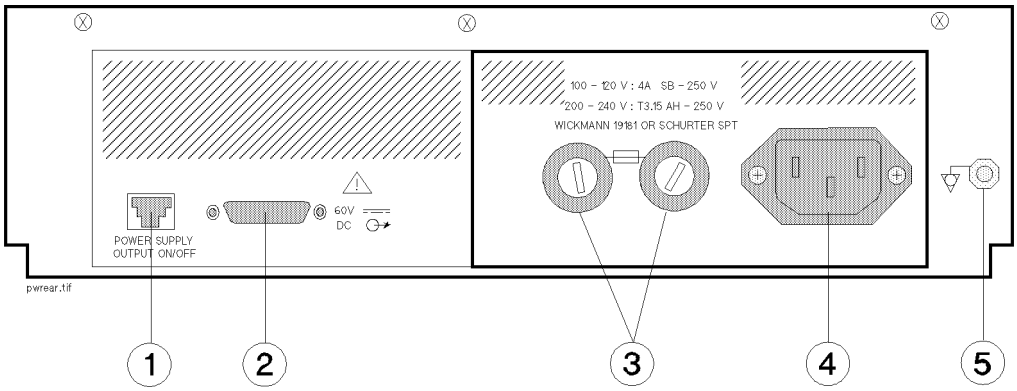


Figure 3-17 Remote Power Supply Rear Panel

Table 3-15 Remote Power Supply Rear Panel Controls and Connectors

	Controls and Connectors	Function
1	Remote ON/OFF Input	This cable connects the Power Supply to the video interface board (located in the CMS Computer Module). It is a female “modular jack” connector with 6-pins, used to input the power supply output ON/OFF signal from the Flatscreen Display.
2	60 V DC (120W max) Output	This is a female 15-pin Sub-D-Type connector, used to output the 60 V dc line voltage to the Computer Module.
3	Fuse Holders	Two fuse holders for the line protection fuses.
4	Local Power Connector	This is a 3-pin connector, used to input the local line voltage.
5	Equipotential Grounding Terminal	This is a grounding stud connector, used to connect the system to an equipotential grounding system.

Display Module

Introduction

The Display Module is the hub of the system's human interface. Its video display terminals and keypads enable users to set and change measurement parameters and alarms, enter and view data on multiple patients, and configure the system's software.

The Display Module also supplies power to the system through its connection to the main power source and its internal power supply.

Each CMS may have up to two independent displays. For 14" CRT displays, each main or independent display can support up to three slave (slave) displays. Main displays have an integral keypad, called a Control Panel, on the front panel, and also support a handheld keypad.

Display Models

Several models of the Display Module are available:

- M1092A 14" Monochrome Display
- M1094A 14" Color Display
- M1094B 14" Color Display
- M1095A 10.4" Flatscreen Color Display
- M1097A 15" XGA Flatscreen Color Display
- M1234B 21" Color Display
- Any off-the-shelf XGA Display

The 10.4", 14" and 15" and off-the-shelf XGA displays can be used as main displays, independent displays, or slave displays. The 21" display is a remote display.

Front of Main Display

The following figures show the front of the main display, which contain a Control Panel and various switches, controls, and connectors.

NOTE

From Rel. B.0 any XGA display can be used as main display. Since these displays do not provide a Control Panel, operation is possible with either the Remote Keypad or, from Rel. C.0, via touchscreen or mouse. The External Alarm Device is required for connections and alarm lights and sounds (please refer to Figure 3-24 "External Alarm Device controls and connectors").

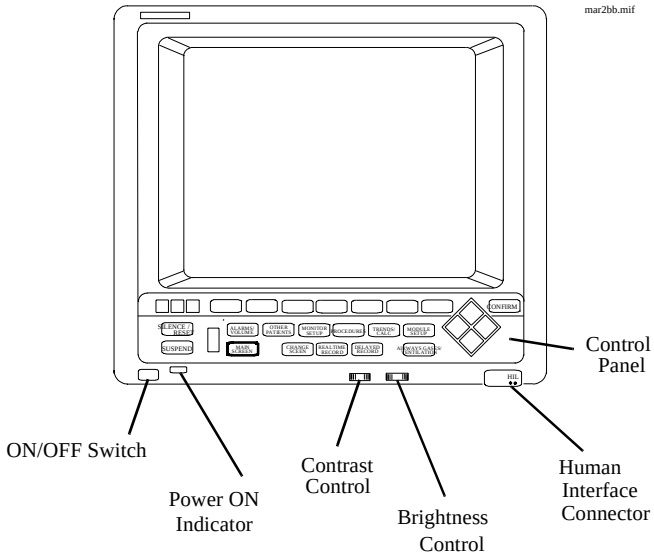


Figure 3-18 Front Panel of Main Display Unit

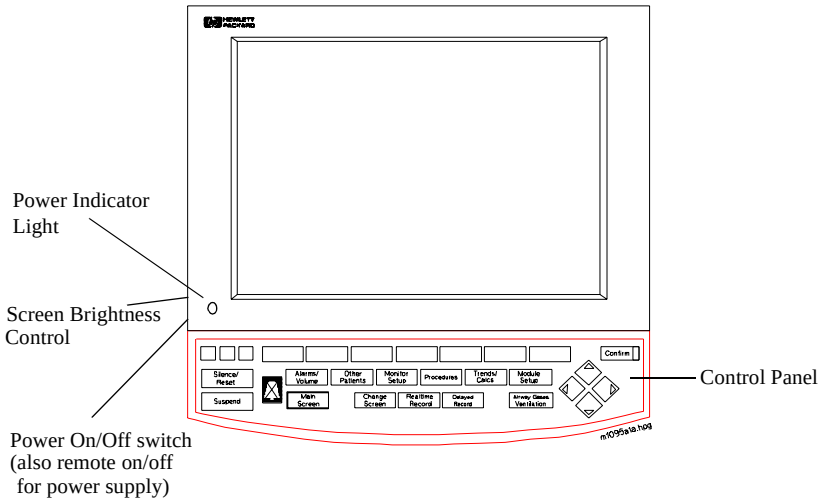


Figure 3-19 Front Panel of 10.4” Flatscreen Display

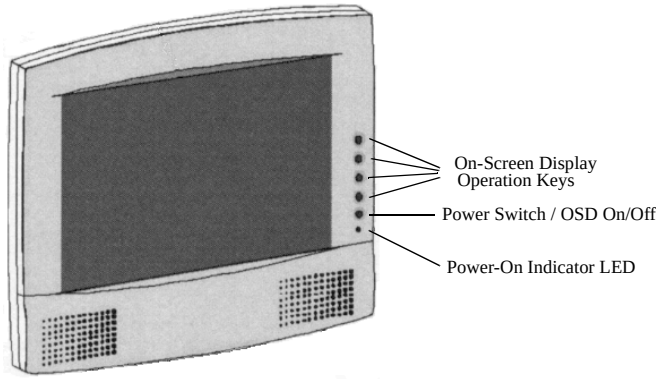


Figure 3-20 Front Panel of 15” Flatscreen Display

Front Panel Controls and Connectors

The following is a description of the control panel on the front of the **CRT** display.

On/Off Switch A push button switch, used to turn the complete system on and off. The switch is pushed in for power on.

Power On Indicator A green LED, which is lit when the system is switched on.

Contrast Control A rotary control, used to vary the contrast of the display (not available on the Flatscreen Display).

Brightness Control A rotary control, used to vary the brightness of the display.

Human Interface Link Connector A Philips-HIL connector, used to input information from a remote keypad connected to the master display. This connector may be covered by a plastic insert when not in use (see rear of flatscreen display for this connector).

Control Panel The user interface of the Display Module. See the following section.

The following is a description of the control panel on the front of the **M1095A 10.4" Flatscreen** display.

On/Off Switch A push button switch, used to turn the display on and off. The switch is pushed in for power on.

Brightness Control A rotary control, used to vary the brightness of the display.

Power On Indicator A green LED, which is lit when the system is switched on.

Control Panel The user interface of the Display Module. See the following section.

Rear of Main Display

The rear of the M1092A and M1094A main displays is shown in Figure 3-21. The rear of the M1094B main display is shown in Figure 3-22 and rear of M1095A in Figure 3-23.

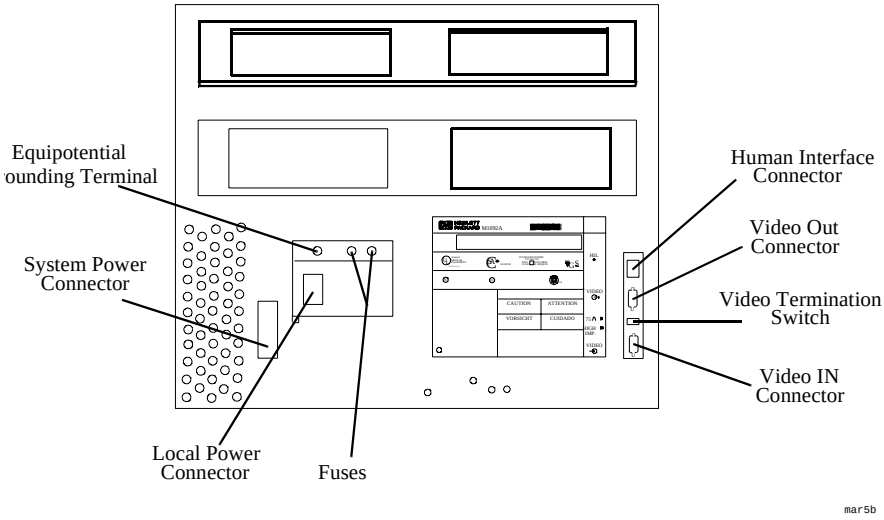


Figure 3-21 Rear of M1092A and M1094A Main Displays

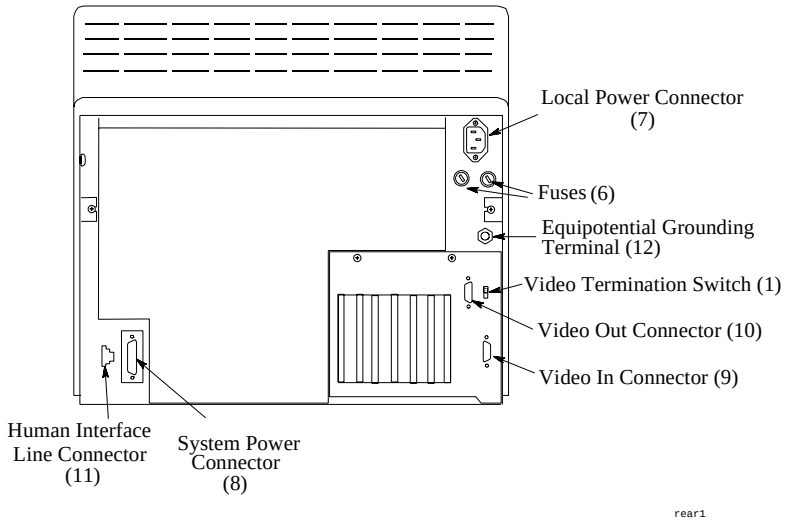


Figure 3-22 Rear of M1094B Main Display

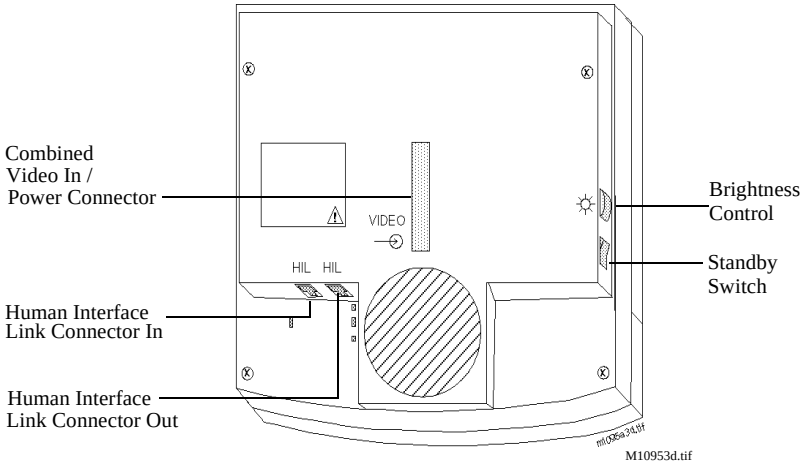


Figure 3-23 Rear of M1095A 10.4" Flatscreen Display

External Alarm Device Connectors and Controls

The External Alarm Device, for use with XGA displays, provides visual and audible alarm indicators. It has a bracket to hold the Handheld Keypad. It also provides an on/off switch to remotely control the M1046B CMS Computer Module.

CAUTION	**Always locate this device in such a way that the speaker at the rear and the lights on the front are not blocked.**

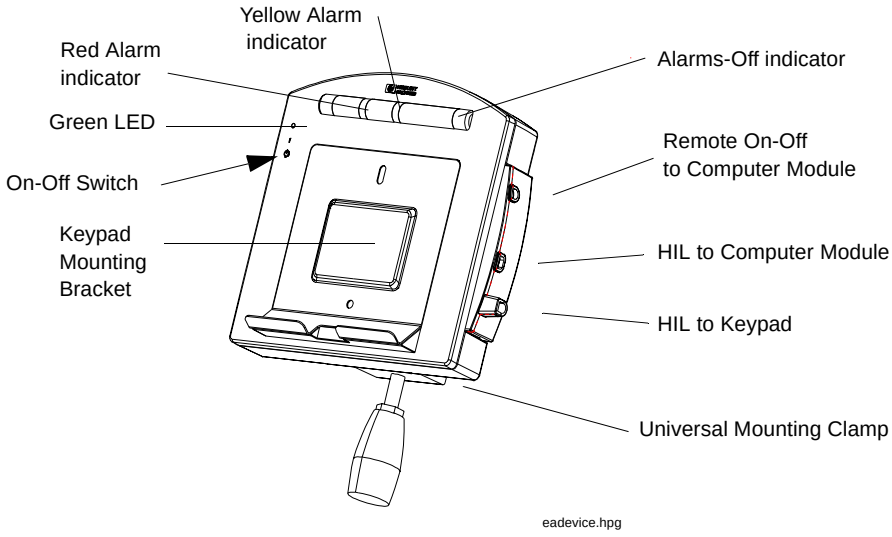


Figure 3-24 External Alarm Device controls and connectors

CRT Display Rear Panel Connectors and Controls

The following is a list of the controls and connectors on the rear of the **CRT** display.

Video Termination Switch

A switch used to terminate the video signal at this display; it must be switched to the 75 Ohm position if only a main display is used. When a remote display is connected, the video termination switch on the main display must be switched to High Imp. However, the last display in the chain must be switched to 75 Ohm.

Fuse Holders

There are two fuse holders for the line protection fuses, one for the higher operating voltage range and one for the lower operating voltage range.

Local Power Connector

A 3-pin connector, used to input the local line voltage. The display is powered directly from the main power source through a 3-pin IEC power inlet plug. A voltage selector is not necessary; the voltage is detected and selected automatically by the display. This works for a voltage range of 90V AC to 264V AC.

The French ICU version has a mains-operated relay with one pair of contacts connected to a mini-phone jack socket. When the power is present, the contacts are closed. Therefore, loss of power breaks the circuit, which can be used to control an alarm.

System Power Connector

When the display is used as a main display, the 60V output at the 15-pin System Power connector is used to power the DC-to-DC converter in the Computer Module. The System Power connector is not present on remote displays.

Equipotential Grounding Terminal

A grounding stud connector, used to connect the display module to an equipotential grounding system, if required. The overall system is normally grounded at the grounding terminal on the Computer Module.

Human Interface Link Connector

The Philips-HIL connector on the rear of the display provides the connection to the Utility CPU in the Computer Module. Another Philips-HIL connector on the bezel of the display allows a handheld keypad to be connected. When this connector is not in use, it may be covered with a blanking plug.

Input and Output Signals

The horizontal sync, vertical sync, and video input signals enter the display through the Video In plug on the rear of the display. For main displays, the input signals are delivered by the video controller card in the Computer Module. For slave remote displays, the signals are from the main display.

The Video Out connector allows a remote display to be daisy-chained to a main or remote display. Up to three remote displays may be connected to the system. The Video Termination switch allows you to select the correct impedance for the display: 1 kOhm if a slave display is connected within the chain and 75 Ohm for the last display in the chain. The switch is a push-button on the M1092A and M1094A displays, a two-pole on the M1094B display.

The following is a list of the controls and connectors on the rear of the **Flatscreen** display.

Brightness Control	A rotary control, used to vary the brightness of the display.
Standby Switch	Controls the M1047A Power Supply 60 V DC output.
Combined Video In/ Power Connector	This is a male SCSI connector with 25 pin pairs used to input the video signal and the 60 V dc line voltage.
Human Interface Link Connector In	This is a Philips-HIL Connector used to connect the handheld keypad.
Human Interface Link Connector Out	This is a Philips-HIL Connector used to output the information from the keypad and control panel to the Utility CPU function card in the computer module.

Switch-Mode Power Supply (SMPS)

The SMPS supplies all the power for the operation of the local equipment and the integral and satellite module racks, including the Plug-in Parameter Modules.

Three types of SMPS are used: one for the M1092A display, one for the 1094A display, and one for the M1094B display. The differences are noted and covered separately in Table 3-16

Table 3-16 SMPS Characteristics

M1092A and M1094A	M1094B Display
A 28V supply is provided for the deflection board of the M1092A Monochrome Display.	
Line voltage is routed through the SMPS to another SMPS on the deflection board of the M1094A Color Display.	One SMPS for all voltages required.
Supplies the de-gausing coils for the display screen. (M1094A/B only)	
Supplies the power-on LED and the Philips-HIL board on the bezel of the display.	
For the main display, it also provides 60V for the Computer Module. The DC-to-DC converter receives the 60V and produces the voltages for the function cards.	

The SMPS in the M1092A and M1094A Displays

The SMPS is connected to the line voltage through a line filter. With the M1094A color display, the line filter is located externally. With the M1092A monochrome display, the line filter is located internally.

Although difficult to see, light from a red LED can be seen through the rear of the SMPS case to show that the 60V is present.

SMPS in the M1094B Display

The SMPS is connected directly to the line voltage.

Human Interface Board

The Human Interface board, shown in Figure 3-25, controls the interface between the user and the system. This board includes the following functions: Philips-HIL control, sound generation and audio power amplification, lamp (LED) control and driver, key pad scanning, key encoding, key code transmission to the Computer Module through the Philips-HIL, and brightness and contrast controls.

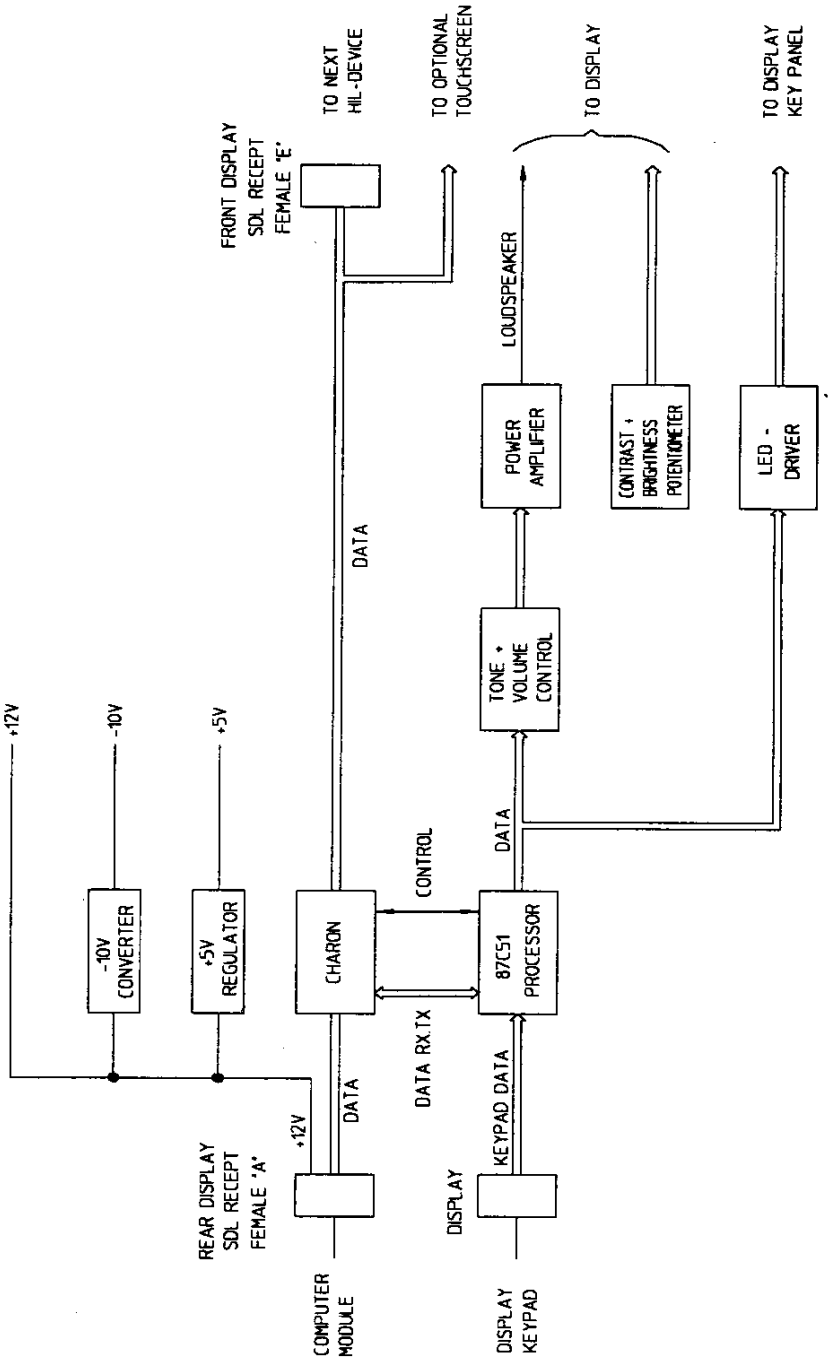


Figure 3-25 Human Interface Board of the Display Unit

Data Transfer

Data transfer to and from the Computer Module in the CMS is performed serially. This is done by the Philips-HIL using the transmit/receive circuit called CHARON. This device sends data in response to a POLL command and receives data from the HIL master using the WRITE REGISTER command.

The data received are used to control the various LEDs on the keypad (for example: visual alarms and key back lighting), activate or trigger the audible tones (for example: alarms, QRS tick, and prompts), and enable or disable on-board functions.

Sound Generation

The Human Interface board generates an audible tone for various conditions. To prevent ambiguity, each condition has its own tone. Each tone has its own control word which controls it. When this control word is sent to the processor, it generates the required tone.

The tones for non-alarm conditions are derived directly from the processor. The alarm tones are processor-generated, based on variable frequency steps.

Volume Control

The Human Interface board has three volume controls: Alarms, QRS tick, and Miscellaneous.

All three controls function in the same manner. The analog tone is applied to the Vref input of a digital-to-analog converter (DAC). The digital input to the DAC is the volume control. The attenuated tone (DAC output) is summed and input to the power amplifier for the loud speaker. The click tone has a fixed volume and is routed to the summing amplifier.

Lamp Control

The Human Interface board controls and drives seven keypad lamps. The processor receives the lamp ON/OFF data and latches a control register/driver.

Key Switches

The processor scans the 25 keys, records a change in switch position, and performs a key bounce function. When a switch position change is registered, the corresponding key code is transmitted to the Philips-HIL master.

Brightness and Contrast

Two rotary controls are provided to adjust the display. The brightness and contrast have part of the control exposed through two holes in the bezel. The brightness control is on the left and the contrast control is on the right.
The brightness control for the flatscreen display is on the rear of the display.

Remote Displays

There are three types of remote (slave) display: 14-inch color, 14-inch monochrome, and 21-inch color. The controls and connections for the 14-inch monochrome and color remote displays are identical.

Video Termination Switch

The only control on the rear panel of the 14-inch remote display is the Video Termination switch. It is a push-button switch, used to terminate the video signal at this display. This switch must be ON (in) if the remote display is the last in the chain. Otherwise the switch must be OFF (out).

There are also two fuse holders for the line protection fuses, one for the low operating voltage range and one for the high operating voltage range. The M1094B is shipped with fuses for 3V and 1.5V.

Control Panel

The main display module contains a Control Panel or integral keypad located on the bezel of the main display module. It is used to allow the user to display different screens on the main and independent displays, respond to alarms, and access the various functions of the system.

The keypad comprises 25 keys and lamps for the alarms on/off and key back-lighting. The controls and indicators on the Control Panel fall into one of three categories: a softkey, hardkey, or an alarm lamp, as shown in Figure 3-26.

The hardkeys are engraved with black letters and their function is always the same. The softkeys, which are the seven keys nearest the screen, are blank. Their function changes during the operation of the system. The current function of each key is displayed as a highlighted block at the bottom of the screen directly over each softkey.

On the right of the keypad are four blank keys arranged as a diamond. They are used to move the highlighted block cursor around the screen. On the left of the keypad is the alarm status indicator and the Silence/Reset and Suspend hardkeys.

The Suspend key is only present on the M1106B and M1106C versions of the integral keypad.

Alarm Lamps

Three alarm lamps are located in the upper left corner of the Control Panel. These lamps are lit when a red or yellow alarm condition exists.

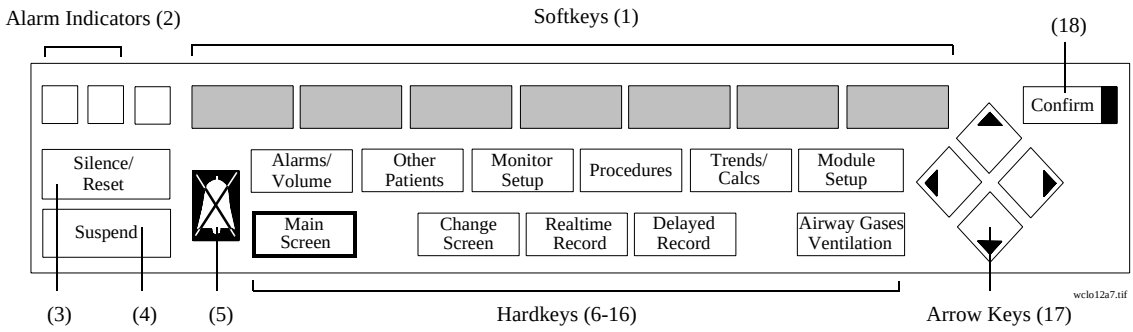


Figure 3-26 Standard Control Panel

Softkeys The function of the control panel softkeys is defined by the application that is current on the display. The label of the key actually appears on the screen and flows to the appropriate softkey. If there is no label on the screen pointing to a softkey, then that key has no function in that application.

Hardkeys The function of a control panel hardkey is defined by the label on the key. The first row of keys, labeled in blue, moves the user to another level of functionality. The second row of keys, labeled in grey, performs actions such as recording a waveform. The hard key descriptions are as follows.

Remote Keypad

Introduction

The Remote Keypad is used to enter data. The keypad has the same softkeys and hardkeys as the Control Panel. It also has data entry keys for entering letters, numbers, punctuation, and arithmetic symbols. The Suspend hardkey is only present on newer versions of the handheld keypad.

Connections

The Remote Keypad is connected to the Philips-HIL connector on the right corner of the bezel on the master display module, or to the outer Philips-HIL connector on the rear of the flatscreen display.

Data Entry Keys

The data entry keys are located at the bottom half of the keypad. To enter the value that is on the key, simply press that key. To enter the value that is above the key, press shift and then the key. Once you are done entering the letters or punctuation marks, press the Shift key.

Note: When the Shift key is pressed, the shift light goes on and stays on until the Shift key is pressed again.

Module Racks

Introduction

The Module Racks are used in the CMS to connect the Plug-In Parameter Modules to the Computer Module. The racks can either be integral to the Computer Module or connected remotely as satellites.

Racks can support either six or eight single-width plug-in modules. The Rack Interface card in the Computer Module can support up to four racks; a CMS may have up to two rack interface cards. The maximum number of Plug-In Modules a CMS can use is 32.

Types of Racks

There are three types of rack: integral, satellite, and blank.

Internal Rack

The internal rack is attached directly to the Computer Module. It can contain up to eight single-width modules and a defibrillator synchronization output connector. It has a satellite rack connector for connecting up to three satellite racks.

Satellite Racks

A satellite rack is mounted away from the Computer Module, usually by the bedside or on an IV pole. It holds either six or eight single-width modules and has a connector for another satellite rack. The M1276A Satellite Rack holds six modules, while the M1041A Satellite Rack holds eight modules.

Satellite Racks are identical in function to the integral rack. However, no defibrillator connector is provided, and the input connector connects to either another satellite rack or to the Computer Module.

Blank Rack

The blank rack is used when the Plug-In Parameter Modules do not require close placement to the Computer Module. The blank rack has only two functions. These are: (1) to provide a path for the Rack Interface connection to the front of the computer module and (2) to provide a defibrillator connection on the front of the computer module.

Integral Rack Connectors

The internal rack has connectors for:

- Eight single-width plug-in modules.
- Three satellite racks.
- A defibrillator connector, for synchronizing the defibrillator firing and receiving a marker pulse.

Satellite Module Rack Connectors

There are three types of connector on the satellite racks. These are described as follows.i

Module Connectors These are female module connectors, used to input the information from the plug-in modules to the rack.

Rack Input Connector This is a male rack interface connector, used to connect the rack to the Computer Module or to the previous rack in the chain.

Rack Output Connector This is a female rack interface connector, used to connect the rack to the next rack in the chain.

Module Rack Theory of Operation

The following section details the operations of the Module Rack.

Power Supply The Module Rack power supply supplies the +5V for the decoding and addressing logic of the rack, as well as for the opto-couplers in the plug-in modules. One secondary winding of the power supply transformer provides the SYNC-Signal for the individual power supplies of the plug-in modules.

Data Transfer The internal module rack provides a communication path, or Front-End Link (FE_LINK), between the Rack Interface card in the Computer Module and the satellite racks as well as the plug-in modules in the internal rack.

Each of the eight plug-in connectors is addressed (by the addressing and decoding logic) and then polled by the Rack Interface Card. If the connector has a module present, then the plug-in module places data about its identity on the Tx line. This Tx line is connected to the Rack Interface card. The Rack Interface places the identities of the plug-in modules into a scan table. (For more information about the FE-LINK and module polling, see Rack Interface Card in the section on Local Function Cards.)

The rack's differential receiver and transmitter ensures the fast and reliable passage of data over the FE-LINK for up to 30 minutes.

Module Rack Block Diagram

The module rack consists of the power system, decoding logic, input, output, and the module connectors.

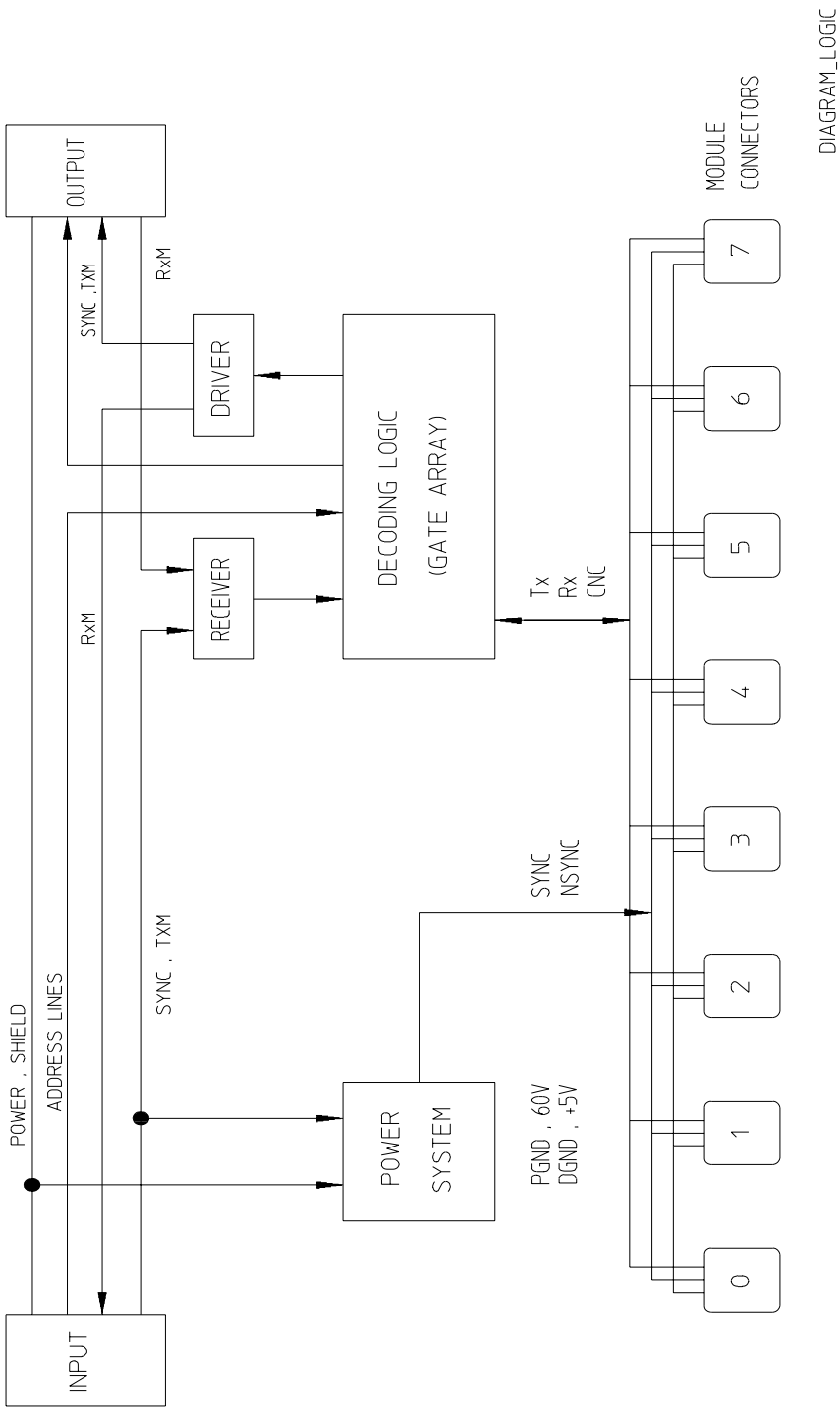


Figure 3-27 Module Racks

Plug-in Parameter Modules

The parameter modules are used to derive physiologic measurements from patients. Several modules do not take measurements but print or transfer data among monitors or external equipment.

Plug-in modules use a variety of accessories for obtaining physiologic data from patients. These may be electrodes, probes, or other types of transducers. The accessories used by each module are color-coded to match the module's connectors for easier identification.

Types of Module

The following types of plug-in module are available for the CMS. Some modules have more than one model for different patient groups or options.

Table 3-17 Plug-In Parameter Modules

Module Name	Measurement
ECG	Electrocardiogram
ECG/RESP	Electrocardiogram/Respiration
ECG/RESP (Option #C01)	Electrocardiogram/Respiration with Analog Respiration Output
PRESS	Invasive Blood Pressure
NBP	Non-invasive Blood Pressure
C.O.	Cardiac Output
CO_2/$SSCO_2$	Carbon Dioxide/Side-Stream Carbon Dioxide
FIO_2	Fractional Inspired Oxygen
$tcpO_2$/$tcpCO_2$/	Transcutaneous Oxygen and Carbon Dioxide Pressures
SpO_2/PLETH	Arterial Oxygen Saturation/Plethysmogram
SvO_2	Mixed Venous Oxygen Saturation
TEMP	Temperature
BLOOD ANALYSIS	Blood Analysis
VueLink	This module does not take measurements. It provides data from external devices.
Recorder	This module does not take measurements. It prints measurements that are being displayed.
Data Transfer	This module does not take measurements. It transfer measurements between monitors.

Alarms

The front of the parameter module has a setup key labeled with the name of the module. For example: the setup key on the ECG module would be labeled ECG. Depending on the module, there may be more keys in addition to the setup key. Pressing the Setup key on a parameter module results in a light appearing above the Setup key.

Installing a Parameter Module

The parameter module slides into the rack until the lever on the base of the module clicks into place. To remove a module, push the lever upwards and pull the module out.

“T” Parameter Module

If a “T” is present on the front of the parameter module, some of the parameter settings may be transferable when that module is moved from rack to rack. There is a special service mode setting that is made by either a Philips service engineer or the biomedical engineering department to allow this function.

Connection to the Rack

The parameter modules can be plugged into two types of rack: integral and satellite. The integral rack is connected to the front of the Computer Module. The satellite rack is a free-standing rack that can be attached to an I.V. pole, the bedside, or the wall.

Connection to the Patient

The front of the parameter module has a connector socket, which is the same color as the corresponding connector plug on the transducer or patient cable.

Precautions

If a satellite rack is located in close quarters with intravenous solutions such as saline, severe damage can occur to the equipment if the saline solution is spilled onto the connectors of either the parameter modules or the satellite rack.

CMS Patient Monitoring System Module Exercises

1. Which CMS module distributes the power, clocks, and data to the rest of the system?

a. Computer Module
b. Display Module
c. Module Rack
d. Plug-In Parameter Modules

2. How many main displays can be used with one CMS?

a. one
b. two
c. three
d. four

3. Which module has a connector for the SDN Interface?

a. Computer Module
b. Display Module
c. Module Rack
d. Plug-In Parameter Modules

4. Which module provides physiologic measurements from patients?

a. Computer Module
b. Display Module
c. Module Rack
d. Plug-In Parameter Modules

5. Which connector is common to both the Computer Module and the Display Module?

a. Analog Interface connector
b. Local Power connector
c. System Power connector

6. Which module supports an integral rack in its front?

a. Computer Module
b. Display Module
c. Module Rack
d. Plug-In Parameter Modules

7. Which module contains a DC-to-DC converter?

a. Computer Module
b. Display Module

c. Module Rack
d. Plug-In Parameter Modules

8. Which module includes a Switch-Mode Power Supply?

a. Computer Module
b. Display Module
c. Module Rack
d. Plug-In Parameter Modules

9. Which module has a Control Panel on its front panel?

a. Computer Module
b. Main Display Module
c. Independent Display Module
d. Plug-In Parameter Modules

10. What is the maximum number of single-width plug-in modules that an integral module rack can hold?

a. four
b. six
c. eight
d. twelve

11. Which module provides a communication path called the Front-End Link?

a. Computer Module
b. Display Module
c. Module Rack
d. Plug-In Parameter Modules

Answers

1. a
2. b
3. a
4. d
5. c
6. a
7. a
8. b
9. b
10. c
11. c

CMS Master Function Cards

Introduction

This section provides detailed information on the master function cards contained in the Computer Module of the CMS. The information includes connections, theory of operation, functional block diagrams, and testing information.

Information on local function cards is contained in another section.

Refer to the Computer Module description in the CMS Modules section for details on card configurations.

Objectives

After successfully completing this module, you should be able to:

- Identify the master function cards used by the CMS.
- Describe the function and operations of each card.

Concepts

The following concepts are important to the operation of master function cards.

Bus Arbitration -- A method of determining which card may have access to a bus at any given time for transmitting messages. Master function cards arbitrate their own access to the Message Passing Bus through an Arbiter function. The Arbiter uses the data's priority level, which is set by the CPU, to gain access to the bus.

Bus Error Logic -- A timer that watches the microprocessor's address strobe for an unusually long activity, indicating that a memory address may be invalid. The logic then asserts a Bus-Error to tell the processor that the memory was not accessed correctly.

FIFO -- First In, First Out. This term indicates the way in which a memory buffer works. With a FIFO buffer, the first data put into the buffer is the first data pulled out. In contrast, a LIFO buffer works the opposite way: the last data put in is the first data pulled out.

EPROM -- Erasable Programmable Read-Only Memory. The EPROM card holds the operating software for the Master Application CPU. If the CPU is a Configurable Processor Card, the EPROM is a Flash EPROM.

The Application CPU card is placed in the lowest-numbered slot on the backplane. At system start-up, this CPU executes the diagnostics and application software.

SRAM -- Static Random Access Memory.

Tune RAM -- A type of RAM used by master cards to listen for data on the Message Passing Bus. It matches message headers that it is storing with headers being transmitted on the bus, in order to determine which messages to read into receive buffers on the bus interface.

Wait State -- The devices that a microprocessor may be required to receive information from, or write information to, may not be as fast as the microprocessor. If the device is slower, the microprocessor can go into a wait state so that the device can complete its current operation before more data are transferred. Wait states are implemented by additional clock cycles being placed into the data sequence.

Topics

This section contains the following topics.

Table 3-18 Topics in the Master Function Card Section

Topic	Page
“Master Card Overview”	3-64
“Application CPU”	3-69
“Configurable Processor Card”	3-74
“Monochrome Display Controller”	3-78
“Color Display Controller Cards”	3-81
“Color Display Controller Card (New Version)”	3-84
“Flatscreen Display Controller Card”	3-87
“Utility CPU”	3-92
“RS232/RS422 Dual Interface Card”	3-98
“HDLC Interface Card”	3-102
“Analog Interface Card”	3-105

Master Card Overview

Introduction

The CMS contains two types of function card: master cards and local cards. Master cards have a microprocessor and connect to the Message Passing Bus (MPB); most also have a connection to the Local Bus. Local cards perform supporting functions for the master cards and connect to only the Local Bus. Master cards communicate with the system over the MPB and with their corresponding local cards over the Local Bus.

Refer to CMS Bus Structure in the System Overview section for a description of the bus architecture.

Master Card Functions

The following table describes the functions of the master cards.

Table 3-19 Master Cards

Card Name	Function
Application CPU APP_CPU	Executes software held on an EPROM Card, an SRAM card, or on the CPU's SRAM. Data to be processed are taken from either the CPU's SRAM, an SRAM Card, or the MPB. The number of Application CPUs that may be used by the Computer Module is limited only by the number of local clusters on the backplane.
Monochrome Display Controller ***DSPC***	Controls the monochrome video display. In addition to this card, the cluster may also contain a language-specific local card such as the DSPC LANG for Asian character set.
Color Display Controller CDSPC_CTRL	Controls the color video display, along with the local card CDSPC VIDEO (if present).
DSPC_FLAT	Controls the Flatscreen Display.
Utility CPU UTIL_CPU	Generates the system clocks for system synchronization and provides the interface to the Philips-HIL devices. The Utility CPU uses the local bus to interface with the SDN and with the Module Racks through the SDN Interface and Rack Interface local cards.
RS232 Interface RS232_IF	Allows the computer module to be connected to external equipment through the use of an RS232 or RS422 interface. This would include equipment such as a local printer or PC.
HDLC Interface HDLC_IF	Provides an interface to real-time wave recorders that use the Standard Recorder Interface Protocol (STRIP). This card does not connect to the local bus.
Configurable Processor Card CPC	Responsible for all application data processing for the CMS. The CPC receives data from the MPB, processes the data, and places the results back on the MPB.
Analog Interface	Provides eight channels of analog output that can be connected to recorders and other data collection instruments.

Communication with the MPB

All master cards contain, as part of their functional components, an MPB Interface that is used to pass data back and forth from the MPB. The MPB Interface consists of a custom IC and an external SRAM. The external SRAM is a pair of receive and transmit FIFO buffers, as shown in Figure 3-28.

Data on the MPB are broadcast to all attached cards for use by any card that requires it. The broadcast message has a header that identifies the type of data contained in the message. The MPB does not designate a particular master card to be solely responsible for bus arbitration; rather, arbitration is determined by the cards themselves.

Taking Data from the MPB Bus

The master card prepares to receive messages by designating desired message types in a memory area called a Tune RAM. The MPB interface reads the header from each message on the bus. If the message header on the bus matches a header in its Tune RAM, the MPB Interface reads the entire message and places the data into one of the receive FIFOs. The data can then be fetched by the CPU. The operation of reading data from the bus is independent of any other operation taking place on the card.

Placing Data on the MPB

Data to be written to the MPB are placed into two Transmit FIFOs by the CPU. When the card receives access to the bus through arbitration, the MPB interface writes the data to the bus.

Bus Arbitration

When a master card wishes to transmit a message on the MPB, the card's CPU assigns the transmit FIFOs a priority level for gaining access to the bus. Each FIFO may have a priority level of Low, Mean, or High. Access to the bus is gained by the Arbiter on the MPB Interface. This task, performed by all the cards connected to the MPB, is how the Computer Module performs bus arbitration for the MPB.

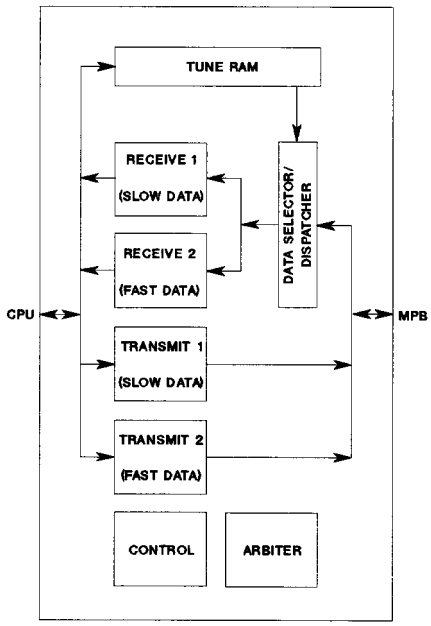


Figure 3-28 Master Card MPB Interface

MPB Messages

MPB messages consist of words that are each 16 bits in length. Each message has a header describing the content of the message, such as ECG Wave Lead 1, and the length of the message. The second part of the message, after the header, is the data.

DC-to-DC Converter

The DC-to-DC converter is a card used in the Computer Module to provide the operating voltages for the rest of the system.

Functional Block Diagram

The functional block diagram of the DC-to-DC converter is shown in chapter 3the following figure.

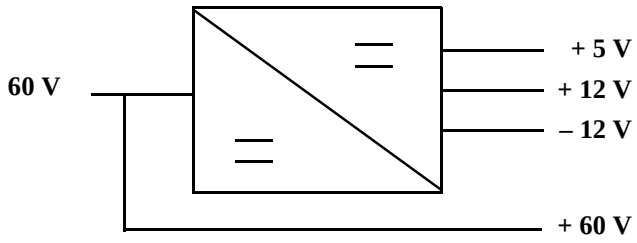


Figure 3-29 DC-to-DC Converter Block Diagram

Theory of Operation

The DC-to-DC converter receives 60V DC as an input from the Display Module. It converts this input to the +5, +12, and -12V DC required for the operation of the system. These voltages, along with the 60V DC, are output onto the Utility bus.

Between the input of the 60V DC and the output of the +5, +12, and -12V DC voltages is a delay of between one to two seconds to make sure that the SYSRES and PFAIL signals are in the proper state.

SYSRES SYSRES is the system reset signal. This signal is usually activated when the system first comes up or when the reset button on a system is pressed. Activating the signal initiates a sequence of events that results in the system clearing out necessary registers and reloading appropriate software to start operations.

PFAIL PFAIL is the powerfail signal. This signal is usually activated very shortly before the power goes down. This is done to initiate a graceful shutdown rather than an abrupt ceasing of operations. This allows cards to save required information or, in some cases, to shut access to their memories in order to prevent corruption of data during the stages of a powerfail.

Power Fail Process If the power fails, the PFAIL signal is asserted by the DC-to-DC converter to alert the Utility CPU that power is going down.

The Utility CPU would then activate the SYSRES on the MPB. This is to allow the system to reset all the cards synchronously.

Application CPU

Introduction

The Application CPU (APP_CPU) card is one type of CPU used to process data in the CMS. This CPU would receive data, process it, and then place the results of the data operation back onto the MPB. The data could be received from its internal SRAM, an SRAM card connected by the Local Bus, or the MPB.

Two versions of Application CPU card are available: the M1054 10 MHz card, and the M1051 15 MHz card. The only functional difference in the two versions is that the 15Mhz has increased processing speed. Even though these CPUs are very similar, they are not interchangeable. A 10 MHz card must be replaced with another 10 MHz card, and a 15 MHz card must be replaced with a 15 MHz card.

The model of the CMS determines which CPU is used, whether both are used, and how many are used.

Components

Both types of Application CPU contain the following functional areas: MPB Interface, FIFO, Local Bus Buffers, Address Decoder and Stack, Output Register, SRAM (buffered), EPROM, and the 68000 Microprocessor. In addition, the 15 Mhz CPU contains a Synchronizer, Wait State Generator, and Clock Generator/Divider.

MPB Interface The MPB Interface is used to interface to the MPB. This is covered in greater detail in the Master Card Overview in this section of the document.

FIFO This is a First In First Out buffer. The data written to the buffer first are the data that are read out first.

Bus Error Logic The bus error logic is simply a timer that watches the microprocessor's address strobe. When the processor outputs an address on its bus, it asserts the address strobe to indicate that a valid memory address is available. However, if the signal is asserted for too long, the logic assumes that the access was not terminated correctly, that is, the address strobe was not negated or removed. The logic then asserts a Bus-Error to tell the processor that it could not access the memory correctly.

Local Bus Buffers The local bus buffers are used to buffer the address between the card and the Local Bus. The data are is also buffered between the bus and the card. These bus buffers connect to the Local Bus, which allows data to be passed between the processor and the local cards in that cluster.

Address Decoder and Dtack The address decoder generates the strobes and select signals for the other devices on the card, such as the SRAM, EPROM, and the MPB Interface. Access acknowledge signals are also generated for all devices except the MPB Interface chip, which generates its own acknowledge signal.

SRAM (buffered) and SRAM

The Static RAM (capacity 512 Kbytes) is used for data storage, such as trends, and may also hold the application software. Note: 64 Kbytes of the 512 Kbytes are buffered by a special capacitor.

EPROM

Also called the BOOT ROM (capacity 64 kilobytes), the EPROM contains firmware start-up code, which locates and identifies the rest of the cards in the cluster.

68000 Microprocessor

The Application CPU Card is based around a 68000 Microprocessor.

Theory of Operation

When the system is turned on, the on-board microprocessor starts to execute code in the EPROM. The code instructs the microprocessor to perform a hardware test of the CPU card. After the hardware test is complete, the Application CPU locates and identifies the other cards in its cluster by using a local card identifier.

The microprocessor on the card then starts to execute the application software. The application software is located on either the EPROM card, if one exists in the cluster, or on the buffered SRAM card.

Memory Location Addressing

Each memory location, on either the CPU card or local memory cards, is addressed using the processor's 23-bit address bus.

Interrupts

There is a support chip to encode interrupts so the processor can react to interrupts. Signals such as power fail (PFAIL) and external interrupt (EXINT) from the Local Bus are treated as interrupts.

LEDs

There are two LEDs connected to the processor through an output latch. These LEDs are controlled by software and are generally used to indicate either errors during the boot phase or the status of the board during normal operation. The rest of the latch is used to generate test signals and identifier access (ACC) signals.

Power Failure & System Reset

The PFAIL signal is used to inform all other function cards that a SYSRES should be expected from the Utility CPU. The SYSRES signal is used to reset all the cards. The PFAIL signal is placed on the Utility Bus by the CPU output latch.

The PFAIL signal is asserted by the Application CPU for two reasons:

(1) the CPU detects that a serious error has occurred in the system, and (2) the watchdog timer detects a failure in the Application CPU.

The PFAIL signal can also be asserted by the DC-to-DC converter when the power is about to fail.

Functional Block Diagram

The functional block diagram of the 10MHz and 15MHz Application CPUs are in Figure 3-30 and Figure 3-31.

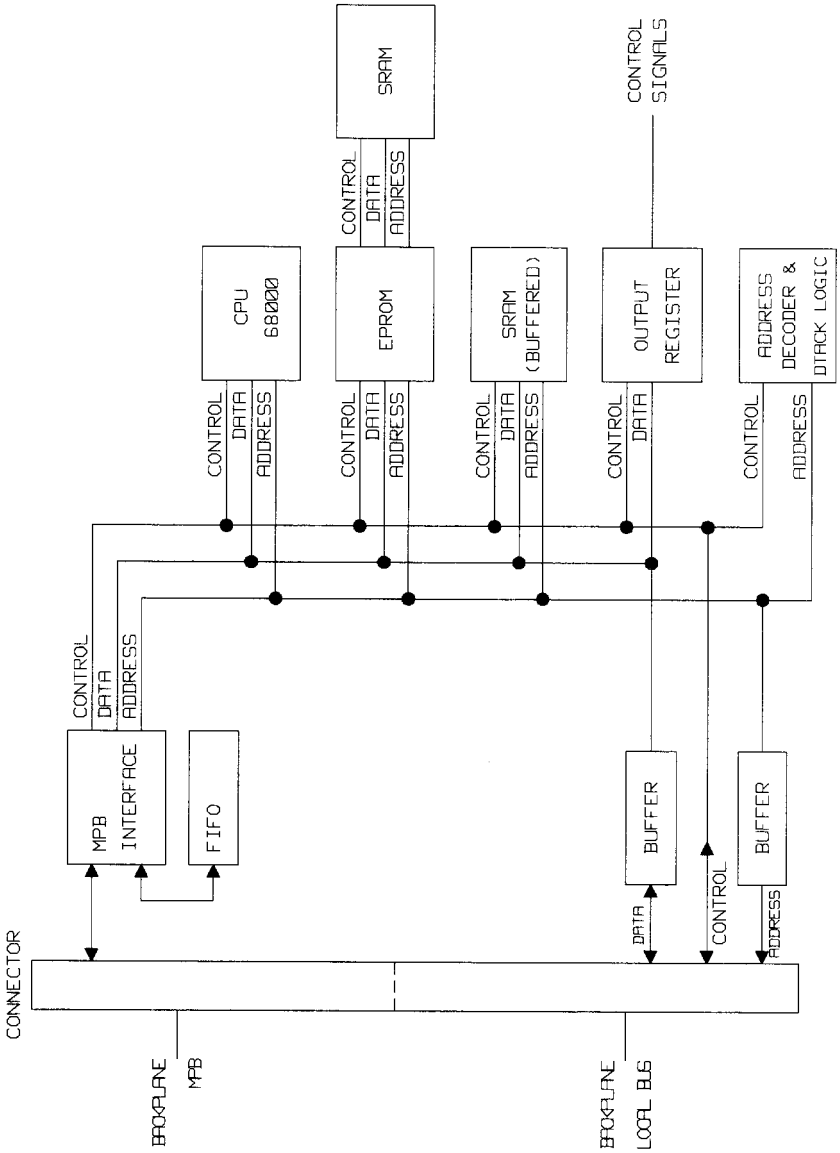


Figure 3-30 10 MHz Application CPU

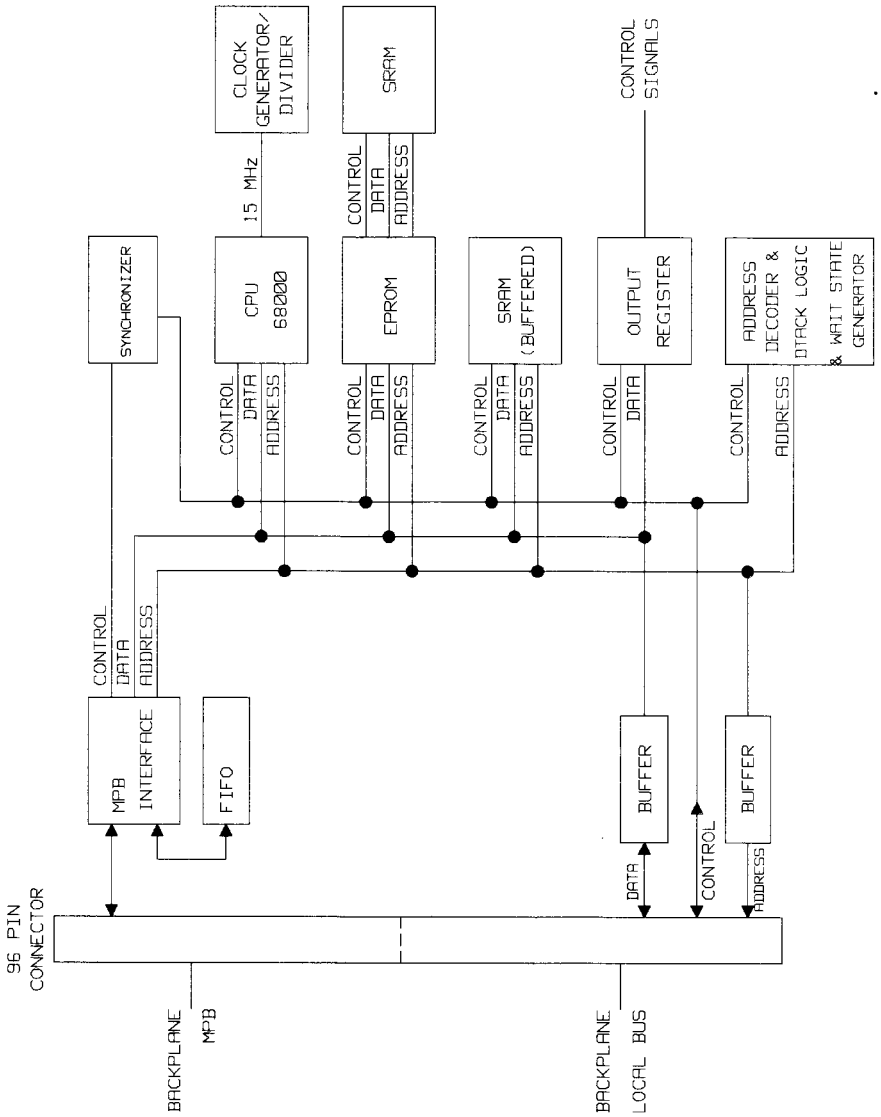


Figure 3-31 15 Mhz Application CPU

LEDs

The Application CPU card contains three LEDs. The function of each is listed in Table 3-20

Table 3-20 Application CPU LEDs

LED	Description
One MPB Error LED (red)	Used to indicate a problem with a device on the board.
Two Error/Status LEDs (green)	Controlled by software, and may be implemented to indicate a hardware failure on the card during the boot phase, when no MPB messages can be sent. When the system is running, they may also be used to reflect the status of the card.

Summary of Functions

The functions of the Application CPU Card are summarized as follows:

- Performs data processing for the system.
- Large volatile SRAM (up to 448 kilobytes) work area for processor.
- Application software is held on an EPROM for the master CPU (the Application CPU card which is placed in the lowest-numbered slot). For subsequent CPUs, the application software is held in SRAM.
- Watchdog facility to detect errors on the CPU Card and report to the system using a PFAIL signal.
- Large parameter trends and other data management results may be stored on a buffered local SRAM Card.
- Three Error / Status LEDs.
- Board Hardware is tested every time the system is reset.
- Power fail protection inhibits access to the on-board buffered SRAM (64 kilobytes). Data retention is better than five hours using a special capacitor.

Configurable Processor Card

Introduction

The Configurable Processor Card (CPC) is a CPU card. It is used to process the application data for the CMS. The CPC receives data from the MPB, processes the data, and places the results of the data processing back on the MPB.

The CMS has two CPC versions available. The first version is a *CPC with Flash EPROM*, which contains on-board flash EPROM for the application memory PROM packs and the boot ROM. The second version is a *CPC with UV EPROM Daughter Card*, which contains on-board flash EPROM for the boot ROM, and a piggyback daughter card, connected to the CPC through two 42-pin connectors. The daughter card contains the application memory PROM packs.

Components

The CPC contains the following functional areas: an 68030 Microprocessor, MPB Interface, a Flash ROM, DRAM, Fast SRAM, Buffered SRAM, Interface, Temp Sensor, Service Port, and Daughter Board Interface.

68030 Microprocessor

The CPC CPU is based on the 68030 microprocessor chip.

MPB Interface

This is the interface between the CPC and the MPB. This interface is covered in greater detail in the opening part of the Master Function Cards section.

Flash EPROM

The Flash EPROM contains the operating software. The flash EPROM is programmed using the CPC programming tool. The EPROM normally has VPP set low (between 4.0V and 4.5V) and functions as read-only memory. The tool operates by setting VPP high (12V) and writing an appropriate instruction to the EPROM.

Two versions of the Flash EPROM are available: M1053-66515 and M1053-66514. The *M1053-66515* contains two types of flash EPROM: a 4 Mb 32 bit wide bank containing the application memory PROM packs, and a 64 Kbyte 8 bit wide bank containing the boot ROM. The *M1053-66514* contains a 64 Kbyte 8 bit wide bank containing the boot ROM. It also contains a non-flash daughter card, the M1061-66501, configured as 768K x 32 bits of memory and occupying up to 3 MB of processor space.

DRAM

The DRAM is used for two purposes: to download programs from the flash EPROM for faster execution, and to provide unbuffered storage for applications. The DRAM is configured as two 32 bit wide banks of 1 MB each.

Fast SRAM

The fast SRAM is used primarily for program execution speed enhancement. The fast SRAM is configured as one 32 bit wide bank.

Buffered SRAM/ SRAM 3-Hour

The buffered SRAM stores application data in the event of a power failure. The buffered SRAM is configured as one 32 bit wide (512 Kbytes) bank and four 8 bit wide (256 Kbytes) banks. All banks are backed up by a super-capacitor to provide a minimum of three hours of storage.

Daughter Board Interface

The interface consists of two 42 pin connectors which is connected to the daughter board.

Address Decoding

The address decoding logic generates strobes and select signals for the on-board devices (MPB, SRAM, EPROM). Access acknowledge signals are also generated for all the devices except the MPB Interface Chip, which generates its own acknowledge signal.

Theory of Operation

The following defines the operations of the Configurable Processor Card.

Interrupts

The CPC contains a support chip to encode interrupts and to present the interrupts to the processor.

Bus Error Logic

The bus error logic consists of a timer that monitors the microprocessor's address strobe. When the processor outputs an address on its bus, it asserts the address strobe to indicate that a valid memory address is available. However, if the signal is asserted for too long, the logic assumes that the access was not terminated correctly, that is, the address strobe was not negated or removed. The logic then asserts a Bus-Error to tell the processor that it could not access the memory correctly.

PFAIL and SYSRES

The PFAIL signal is used to inform all other function cards that a SYSRES should be expected from the Utility CPU. This is to allow the system to reset all cards synchronously. One bit of the CPU output latch is used to place PFAIL on the utility bus.

The PFAIL signal is asserted for two reasons by the CPU: (1) if the CPU detects that a serious error has occurred in the system, and (2) if the watchdog timer in the MPB-chip detects a failure in the CPU. Note: the PFAIL signal may also be asserted by the DC-to-DC converter.

DRAM Refresh

The DRAM refresh is controlled by the microprocessor. A 3.2768 millisecond timer interrupts the processor at set intervals to do the refresh cycle. The refresh cycle is accomplished by the processor writing to a single address. The DRAM chips cycle through the banks each time a refresh is performed.

Functional Block Diagram

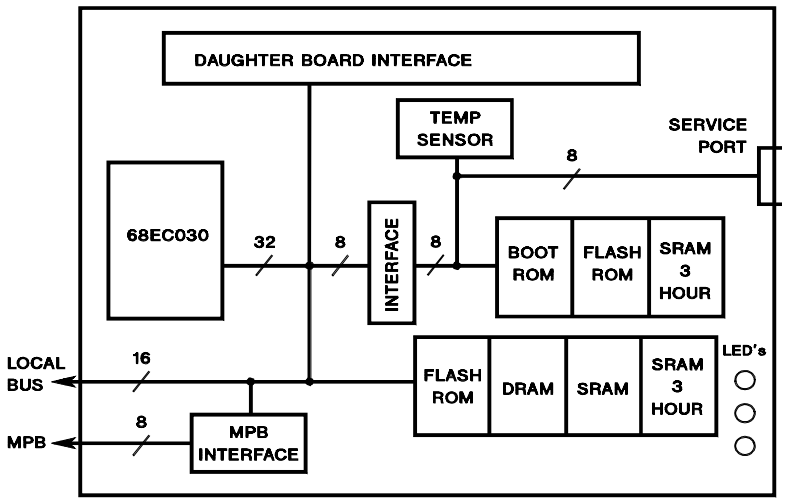


Figure 3-32 CPC Card Block Diagram

Daughter Card Block Diagram

The daughter card contains the following functional areas: Output Enable Decoder, Memory Select PAL, Address Buffer, and the ROM Banks.

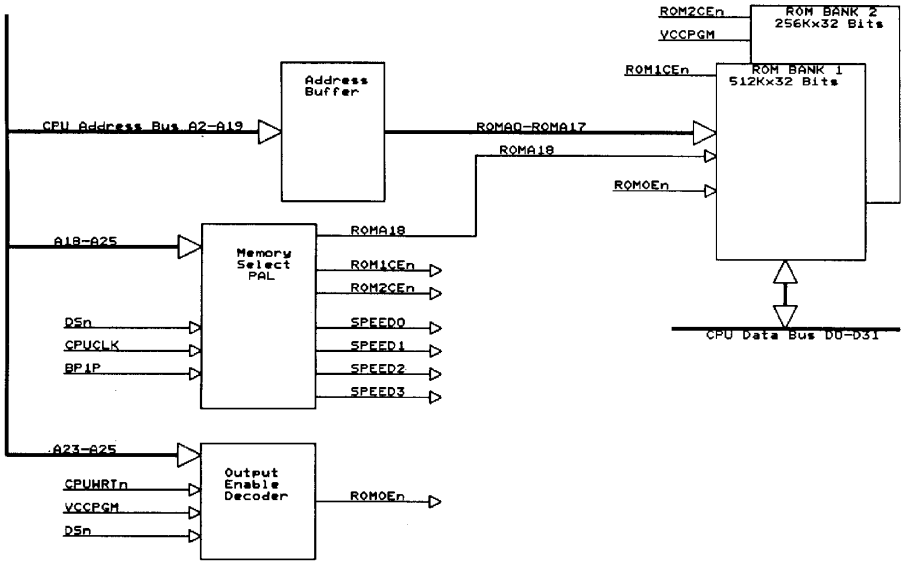


Figure 3-33 Daughter Card Block Diagram

CPC LEDs

The LEDs on the CPC are defined inTable 3-21.

Table 3-21 CPC LEDs

LED	Description
One MPB Error LED (red)	Used to indicate a problem with a device on the card.
Two Error/Status LEDs (green)	Controlled by software, and may be implemented to indicate a hardware failure on the card during the boot phase, when no MPB messages can be sent. When the system is running, they may also be used to reflect the status of the card.

Summary of CPC CPU Features

The following is a summary of the CPC CPU features.

- Processes the application data.
- Contains a large SRAM and DRAM work area for the processor.
- Includes a watchdog timer to detect errors on the CPU and report to the system using a PFAIL signal.
- Error / Status LEDs.
- Card hardware is tested every time the system is reset.
- Power fail protection inhibits access to the on-board buffered SRAM.
- Provides a minimum of three hours of data retention in SRAM using a super-capacitor.

Monochrome Display Controller

Introduction

The Display Controller (DSPC) card is used by the system to output display data to a main monochrome display and up to three remote displays. A second DSPC card is required if the system has to produce two different displays. The second DSPC card is plugged into a separate cluster.

The DSPC card is a master card, based on a 68000 Microprocessor, with a connection to the local bus.

Connection to Display Module

The DSPC card must be connected to the display; therefore, it is plugged into the rear of the Computer Module rather than into the front. The DSPC card has a 9-pin, D-type connector on the card edge, which is used to connect to a similar connector on the rear of the Display Module. Note: the video output connector on the display can be used to connect to a remote display.

Components

The DSPC card contains the following functional areas: a 68000 Microprocessor, MPB Interface, FIFO, EPROM, SRAM, Horizontal Wavescroll Logic, Video System Controller, Pixel Maps, SLIP Chip, Video Buffer and Protection Network, and Oscillator.

68000 Microprocessor The 68000 is the microprocessor used on this card.

MPB Interface The MPB Interface is used to read and write data to the MPB. For more information refer to the beginning of the Master Function Cards section.

FIFO First In First Out buffer.

EPROM The EPROM is used to hold the code to be executed at powerup.

SRAM The SRAM holds data during operation of the card.

Video Ram The video RAM has four parts:

Table 3-22 Video RAM Functionality

Plane/Map	Description
Alphanumerics / Graphics plane 1	(Each plane is 1024 x 512 pixels.) The two alphanumeric / graphics planes display text, figures and basic graphics (lines, boxes etc.).
Alphanumerics / Graphics plane 2	

Table 3-22 Video RAM Functionality

Plane/Map	Description
Wave Plane	(2048 x 512 pixels) This higher resolution wave plane displays the parameter waves, such as ECG.
Attribute Map	(256 x 256 bytes) The attribute map enables parts of the screen and selects between full-, half-brightness and blinking.

Theory of Operation

The DSPC only controls the mechanism of actually displaying information on the screen. More than one CPU may be required to produce data for the display.

All display data, including local language characters, are produced by the CPUs and transferred using the MPB.

Data Transfers

Display data, waves, lines, numerics, display attribute data, and control messages are transferred from the CPUs using the MPB to the DSPC. The microprocessor on the DSPC places these data into the dual-ported Video RAM using a Video System Controller. Display attributes -- for example, half-brightness -- are also placed in the Video RAM.

The pixel data are clocked out of the Video RAM by the on-chip shift registers. These data then pass through the SLIP Chip, which contains all the video and addressing logic, before passing it to the video buffers. The data then pass through the protection network for output to the display; an oscillator is used to synchronize the picture sweep.

Wave Plane

The wave plane, used for displaying up to six overlapping parameter waves, is implemented in a different way than for the other planes. The reason for this is that the wave plane must display waves that scroll horizontally on the monitor. The scrolling logic moves a pointer, indicating the left of the screen, through the video RAM and new data are written directly behind it. This has the result of moving the trace by adding new data onto the right of the screen as old data are displaced on the left.

Character Sets

The Japanese, Taiwanese, and Chinese character sets are too large to be handled by the standard EPROM cards. These characters are therefore stored on a dedicated EPROM card, the DSPC Language card, which is placed in the same cluster as the Display Controller.

Functional Block Diagram

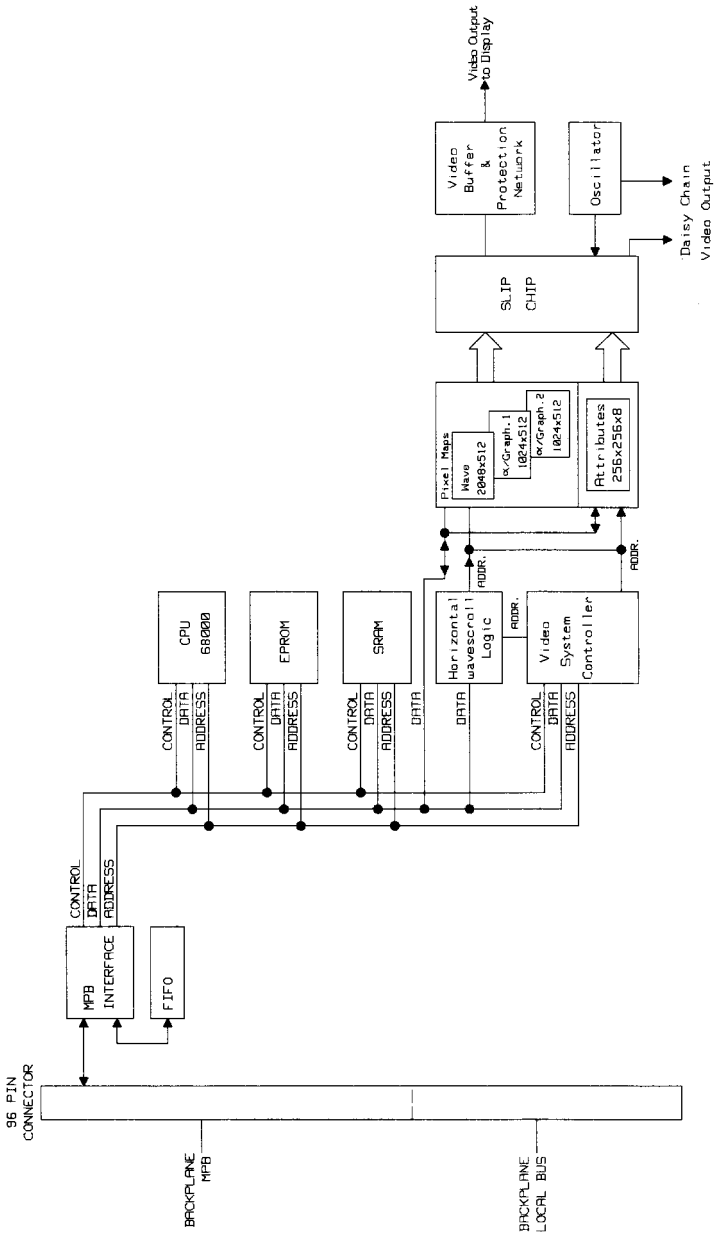


Figure 3-34 DSPC Card Block Diagram

Summary of DSPC Card Features

The features of the DSPC card are as follows:

- Two alphanumeric/graphic planes (1024 x 512 pixels) for display text, figure and simple graphics.
- One wave plane with extended resolution (2048 x 512 pixels) that can display up to six overlapping waves with horizontal scrolling.
- Three character sizes: large = 32 x 40 pixels, normal = 16 x 20 pixels, and dense = 12 x 16 pixels.
- Attributes resolution 256 x 256 bytes.
- Can drive slave displays.
- 60 Hz operation.

Color Display Controller Cards

Introduction

The Color Display Controller (CDSPC) cards are a set of two cards used by the system to output display data to a color monitor. The CDSPC cards are similar in operation to the DSPC card, with the exception that the Video RAM is three times larger. Therefore, two cards are required: CDSPC_CTRL and CDSPC_VIDEO.

The CDSPC_CTRL card, the video controller, is a master card connected to the MPB Bus and the Local Bus. The CDSPC_VIDEO card is a local card that contains the Video RAM and output circuits to the Display Module. The two cards are connected by the Local Bus.

Connections

Both cards must be placed in the same cluster of the Computer Module. The CDSPC_VIDEO card must be inserted into the rear of the Computer Module so that it can be connected to the display. It is connected to the display by using a cable between the 9-pin, D-type connector on the card edge and a similar connector on the rear of the display. The video output on the rear of the display may be used to connect a remote display.

If Kanji characters are to be supported, the EPROM and DSPC_KANJI cards must also be inserted into the same cluster as the two CDSPC cards.

Each pair of CDSPC cards supports either one master display and three remote displays or four remote displays. If the system is required to produce two different color displays, a second pair of CDSPC cards must be used in a separate cluster.

For details on the components and operation of the CSDPC_VIDEO card, refer to the Local Functional Cards section of this chapter, “Local Card Overview” on page 3-111.

CDSPC_CTRL Components

The video controller card consists of the following functional areas: 68000 Microprocessor, MPB Interface, FIFO, SRAM, PROM, Extension PROM, and buffer.

68000 Microprocessor

The CDSPC_CTRL card is based on the 68000 Microprocessor.

MPB Interface

The MPB Interface is used to pass data back and forth between the card and the MPB. For more information, refer to the beginning of the Master Functional Cards section, “Master Card Overview” on page 3-64.

FIFO

First In First Out buffer.

SRAM

The SRAM contains code for communications with the CDSPC_VIDEO card.

PROM

The PROM contains the firmware for communications with the CDSPC_VIDEO card.

Theory of Operation

The CDSPC-CTRL card acts as an interface between the system and the video card. The CDSPC-VIDEO card connects the Computer Module to the display.

The CDSPC cards only control the mechanism of actually displaying information on the screen. All display data, including local language characters and color information, are produced by the Application CPUs or CPCs. More than one CPU may produce data for the display.

Data Transfer

The CDSPC controller card receives display data, waves, lines, numerics, display attribute data and control messages from the CPU over the MPB. The microprocessor on the controller card sends the data over the Local Bus to the video card. The Video System Controller on the video card places the data into the dual-ported Video RAM. Display attributes, such as half-brightness are also placed in the Video RAM.

The pixel data is clocked out of the Video RAM by the on-chip shift registers. This data then passes through the SLIP Chip which contains all the video and addressing logic before passing it to the video buffers. The data then passes through the protection network for output to the display. An oscillator is used to synchronize the picture sweep.

Character Sets

The Japanese, Taiwanese and Chinese character sets are too large to be stored on the standard EPROM cards. These characters are therefore stored on a dedicated EPROM card, the DSPC Language card, which is placed in the same cluster as the display controller cards.

CDSPC_CTRL Functional Block Diagram

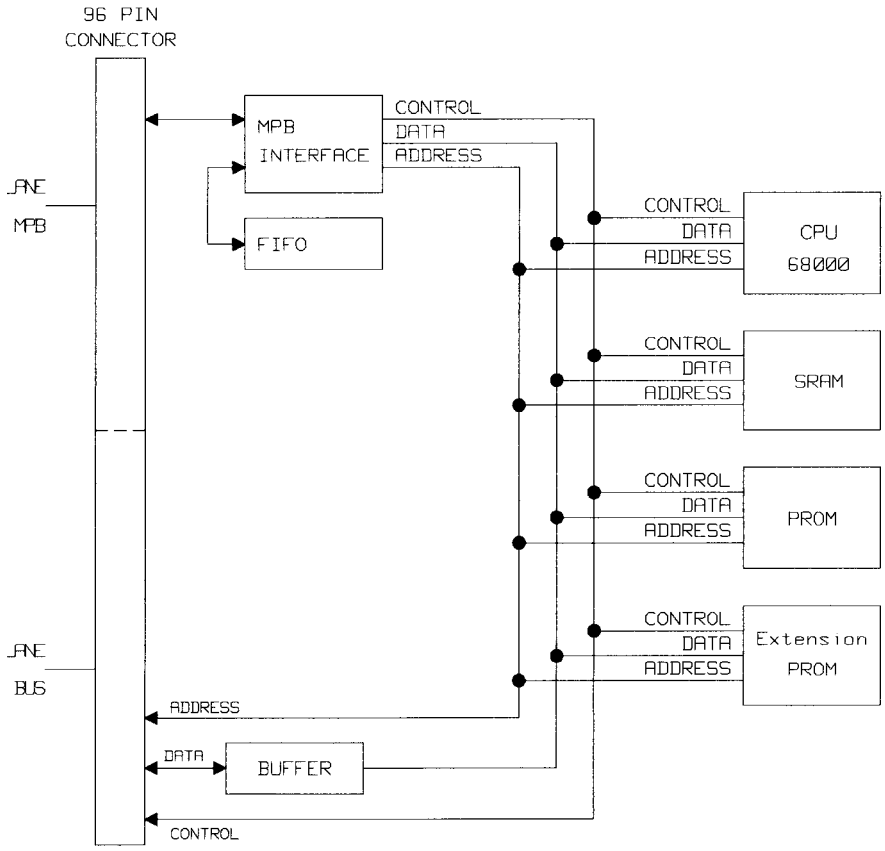


Figure 3-35 CDSPC_CTRL Card Block Diagram

Summary of CDSPC Cards Features

A summary of the features of the CDSPC cards follows.

- Displays up to 8 overlapping waves in 7 colors, with horizontal scrolling.
- Two alphanumeric/graphic planes (1024 x 512 pixels x 3 color banks) for displaying text, figures, and simple graphics.
- One wave plane with extended resolution (2048 x 512 pixels x 3 color banks) that can display up to 8 overlapping waves with horizontal scrolling.
- Three character sizes: large = 32 x 40 pixels, normal = 16 x 20 pixels, dense = 12 x 16 pixels.
- Attributes resolution 256 x 256 bytes.
- Can drive a master and up to 3 remote displays.
- Color luminance equalization.
- 60 Hz operation.

Color Display Controller Card (New Version)

Introduction

The Color Display Controller (CDSPC) card is used by the system to output display data to a color monitor. The CDSPC card is similar in operation to the DSPC card, with the exception that the Video RAM is three times larger. The CDSPC was introduced as a direct replacement for two cards, CDSPC_CTRL and CDSPC_VIDEO and has the same functionality as these cards. The CDSPC is fully backwards compatible.

Connections

The CDSPC card must be inserted into the rear of the Computer Module so that it can be connected to the display. It is connected to the display by using a cable between the 9-pin D-type connector on the card edge and a similar connector on the rear of the display. The video output on the rear of the display may be used to connect a remote display.

If Asian characters are to be supported, the DSPC_LANG card must also be inserted into the same cluster as the CDSPC card.

Each CDSPC card supports either one master display and three remote displays, or four remote displays. If the system is required to produce two or three (slave) different color displays, a second or third CDSPC card must be used in a separate cluster.

CDSPC Components

The video controller card consists of the following functional areas: 68000 Microprocessor, MPB Interface, FIFO, SRAM, PROM, Extension PROM, and buffer. The video component of the card consists of: Color Register, Buffer, Horizontal Wave Scroll Logic, Video System Controller, Attributes, Oscillator, Video Buffers, Color Mapping Circuit, Protection Network, and the Color Planes.

68000 Microprocessor The CDSPC card is based on the 68000 Microprocessor.

MPB Interface The MPB Interface is used to pass data back and forth between the card and the MPB. For more information, refer to the beginning of the Master Functional Cards section.

FIFO First In First Out buffer.

SRAM The SRAM contains code for communications with the CDSPC_VIDEO card.

PROM The PROM contains the firmware for communications with the CDSPC_VIDEO card.

Theory of Operation

Color Register

The color register chooses the color.

Video System Controller

The three color banks of the Video RAM are controlled by the Video Controller chip.

Video RAM

The video RAM has four parts as shown in the following table.

Table 3-23 Video RAM Components

Pane/Map	Description
Alphanumerics / Graphics plane 1	(1024 x 512 pixels x 3 color banks) The two alphanumeric / graphics planes are used to display text, figures, and basic graphics (lines, boxes etc.).
Alphanumerics / Graphics plane 2	
Wave Plane	(2048 x 512 pixels x 3 color banks) The higher resolution wave plane is used for displaying the parameter waves, such as ECG.
Attribute Map	(256 x 256 bytes) The attribute map is used to enable parts of the screen and select between full-brightness, half-brightness, and blinking.

The CDSPC card controls the mechanism of actually displaying information on the screen. All display data, including local language characters and color information, are produced by the Application CPUs or CPCs. More than one CPU may produce data for the display.

Data Transfer

The CDSPC card receives display data, waves, lines, numerics, display attribute data and control messages from the CPU over the MPB. The microprocessor on the controller card sends the data over the Local Bus to the video card. The Video System Controller places the data into the dual-ported Video RAM. Display attributes, such as half-brightness are also placed in the Video RAM.

The pixel data is clocked out of the Video RAM by the on-chip shift registers. This data then passes through the SLIP Chip which contains all the video and addressing logic before passing it to the video buffers. The data then passes through the protection network for output to the display. An oscillator is used to synchronize the picture sweep.

Character Sets

The Japanese, Taiwanese and Chinese character sets are too large to be stored on the standard EPROM cards. These characters are therefore stored on a dedicated EPROM card, the DSPC Language card, which is placed in the same cluster as the display controller cards.

Wave Plane

The wave plane displays up to eight overlapping parameter waves. This plane is implemented in a different way than for the other planes, because the wave plane must display waves that scroll horizontally on the screen. The scrolling logic moves a pointer, indicating the left of the screen, through the Video RAM, and new data is written directly behind it. This has the result of adding new data onto the right of the screen as old data is displaced on the left.

Color Equalization

The seven colors produced by the color display have their intensities equalized, so that they appear similar in intensity to the human eye. This is done by using a resistor network in combination with some transistors; red and green are added to lighten the output of the blue output on the display. The red output has a slightly higher full intensity voltage to get brighter alarms.

CDSPC Functional Block Diagram

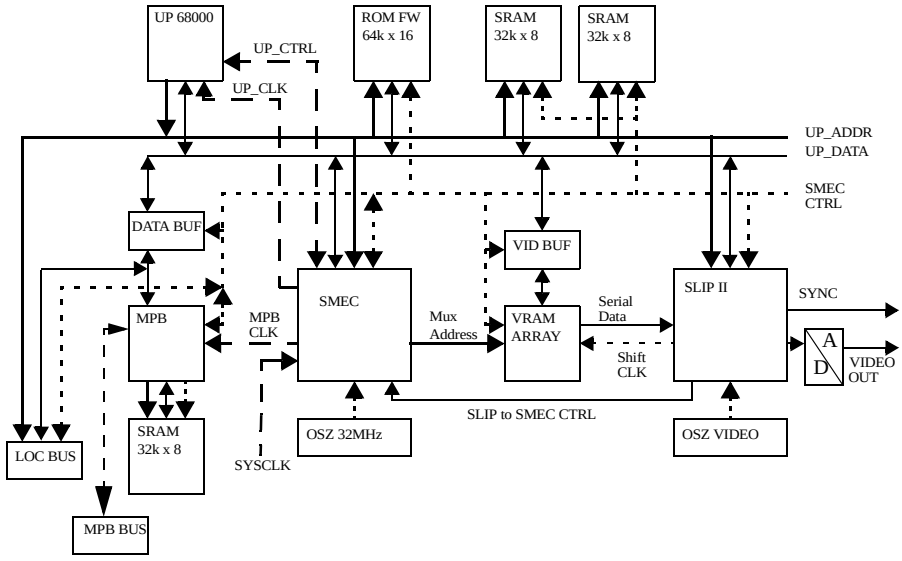


Figure 3-36 CDSPC Card Block Diagram

Summary of CDSPC Cards Features

A summary of the features of the CDSPC cards follows.

- Displays up to 8 overlapping waves in 7 colors, with horizontal scrolling.
- Two alphanumeric/graphic planes (1024 x 512 pixels x 3 color banks) for display text, figures, and simple graphics.
- One wave plane with extended resolution (2048 x 512 pixels x 3 color banks) that can display up to 8 overlapping waves with horizontal scrolling.
- Three character sizes: large = 32 x 40 pixels, normal = 16 x 20 pixels, dense = 12 x 16 pixels.
- Attributes resolution 256 x 256 bytes.

- Can drive a master and up to 3 remote (slave) displays.
- Color luminance equalization.
- 60 Hz operation.

Flatscreen Display Controller Card

Introduction

The Flatscreen Display Controller (DSPC_FLAT) card is used by the system to output display data to the Flatscreen.

Connections

The DSPC_FLAT card must be inserted into the rear of the Computer Module so that it can be connected to the flatscreen display. It is connected to the display by using a cable between the 25-pin SCSI connector on the card edge and a similar connector on the rear of the display.

If Asian characters are to be supported, the DSPC_LANG card must also be inserted into the same cluster as the DSPC_FLAT card.

Each DSPC_FLAT card supports one master display - no remote (slave) displays can be connected. If the system is required to produce two different flatscreen displays, a second DSPC_FLAT card must be used in a separate cluster.

60 V power for the flatscreen display itself is fed through the DSPC_FLAT via a fuse. The remote on/off connection from the flatscreen display to the external power supply is fed directly from J2 to J3.

DSPC_FLAT Components

The DSPC_FLAT card consists of the following functional areas: 68000 Microprocessor, MPB Interface, SRAM, PROM, buffer, VRAM and Video Control Logic. The DSPC_FLAT card is based on the 68000 Microprocessor. The MPB Interface is used to pass data back and forth between the card and the MPB. For more information, refer to the beginning of the Master Functional Cards section.

Theory of Operation

The DSPC_FLAT card controls the mechanism of actually displaying information on the screen. All display data, including local language characters and color information, are produced by the Application CPUs or CPCs. More than one CPU may produce data for the display.

Data Transfer

The DSPC_FLAT controller card receives display data, waves, lines, numerics, display attribute data and control messages from the CPU over the MPB. The Microprocessor places the data into the dual-ported Video RAM. Display attributes, such as half-brightness are also placed in the Video RAM.

The pixel data is clocked out of the Video RAM by the on-chip shift registers. This data then passes through the SLIP Chip which contains all the video and addressing logic before passing it to the video buffers. The data is transmitted differentially to the Flatscreen.

Character Sets

The Japanese, Taiwanese and Chinese character sets are too large to be stored on the standard EPROM cards. These characters are therefore stored on a dedicated EPROM card, the DSPC Language card, which is placed in the same cluster as the DSPC_FLAT card.

DSPC_FLAT Functional Block Diagram

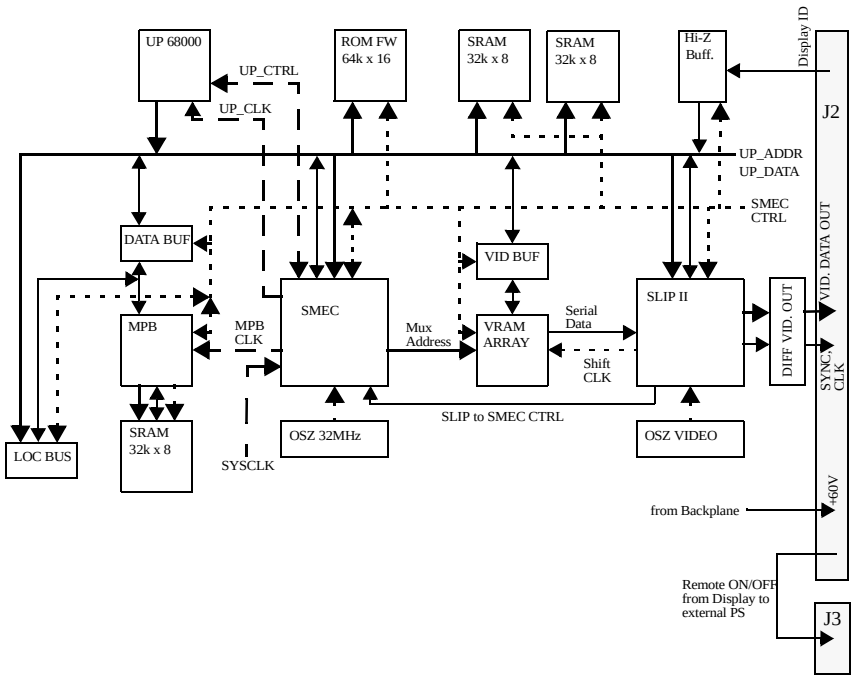


Figure 3-37 DSPC_FLAT Card Block Diagram

Summary of DSPC_FLAT Card Features

A summary of the features of the DSPC_FLAT card follows.

- Displays up to 8 overlapping waves in 7 colors, with horizontal scrolling.
- Two alphanumeric/graphic planes (640 x 480 pixels x 3 color buffers) for displaying text, figures, and simple graphics.
- One wave plane with resolution (640 x 480 pixels x 3 color buffers) that can display up to 8 overlapping waves with horizontal scrolling.
- Three character sizes:
  large = 20 x 36 pixels, standard = 10 x 18 pixels, dense = 7 x 14 pixels.
- Attributes resolution 320 x 480 cells.
- Can drive a master flatscreen.
- Color luminance equalization.
- 60 Hz operation.

DSPC_FLAT_ASIA Flatscreen Controller Card

Introduction

The DSPC_FLAT_ASIA controller card is a replacement for the DSPC_FLAT controller card. This improved controller is backwards compatible and can be used to replace the DSPC_FLAT in M1046A Computer Modules that have a flatscreen as a main display and use the M1074A Remote Power Supply to power the system.

Additionally, the remote switch path is also connected to the backplane so that it can be used with the M1046B Computer Module that is powered by its integral power supply. The original DSPC_FLAT **cannot** be used in the M1046B for the main flatscreen display.

This controller provides an Asian/Eastern Europe language option consisting of a 4-way DIP-switch and a Multilanguage ROM allowing character sets for Japanese, Taiwanese, Chinese, Russian, Greek, Polish and Czech to be selected. Therefore, this controller does not need a DSPC_LANG card.

Connections

All connections are the same as that for the DSPC_FLAT controller. In addition, the remote switch is also routed to the backplane for M1046B compatibility.

DSPC_FLAT_ASIA Components

The circuit design for the flatscreen controller remains unchanged from the original DSPC_FLAT controller. Additional components have been added to route the remote switch to the blackplane.

These two parts of the circuit communicate over the local bus as if they were two separate cards on the same cluster.

Theory of Operation

This is the same as the original DSPC_FLAT controller card.

Summary of Features

All the features of the original DSPC_FLAT are supported. Additional features for the DSPC_FLAT_ASIA controller are as follows.

- Compatible with the M1046B Computer Module.
- Provides an Asian and Eastern Europe multi-language package.
- Selectable Asian languages: Japanese, Taiwanese and Chinese. The language package can be disabled.
- Selectable Eastern Europe languages: Russian, Greek, Polish, Czech. The language package can be disabled.

DSPC_XGA Display Controller Card

Introduction

The XGA Display Controller (DSPC_FLAT) card is used by the system to output display data to a XGA compatible display.

Connections

The DSPC_XGA card must be inserted into the rear of the Computer Module so that it can be connected to the display. It is connected to the display by using a cable between the 15-pin XGA connector on the card edge and a similar connector on the rear of the display.

Each DSPC_FLAT card supports one master display - no remote (slave) displays can be connected. If the system is required to produce two different XGA displays, a second DSPC_XGA card must be used in a separate cluster.

The remote on/off connection from the Remote Alarm Device to the M1046B integral power supply is fed directly from J2 to J3.

DSPC_XGA Components

The DSPC_XGA card consists of the following functional areas: 68000 Microprocessor, MPB Interface, SRAM, PROM, buffer, VRAM and Video Control Logic. The DSPC_XGA card is based on the 68000 Microprocessor. The MPB Interface is used to pass data back and forth between the card and the MPB. For more information, refer to the beginning of the Master Functional Cards section.

Theory of Operation

The DSPC_XGA card controls the mechanism of actually displaying information on the screen. All display data, including local language characters and color information, are produced by the Application CPUs or CPCs. More than one CPU may produce data for the display.

Data Transfer

The DSPC_XGA controller card receives display data, waves, lines, numerics, display attribute data and control messages from the CPU over the MPB. The Microprocessor places the data into the dual-ported Video RAM. Display attributes, such as half-brightness are also placed in the Video RAM.

The pixel data is clocked out of the Video RAM by the on-chip shift registers. This data then passes through the SLIP Chip which contains all the video and addressing logic before passing it to the video buffers. The data is converted to analogue XGA video signals.

DSPC_XGA Functional Block Diagram

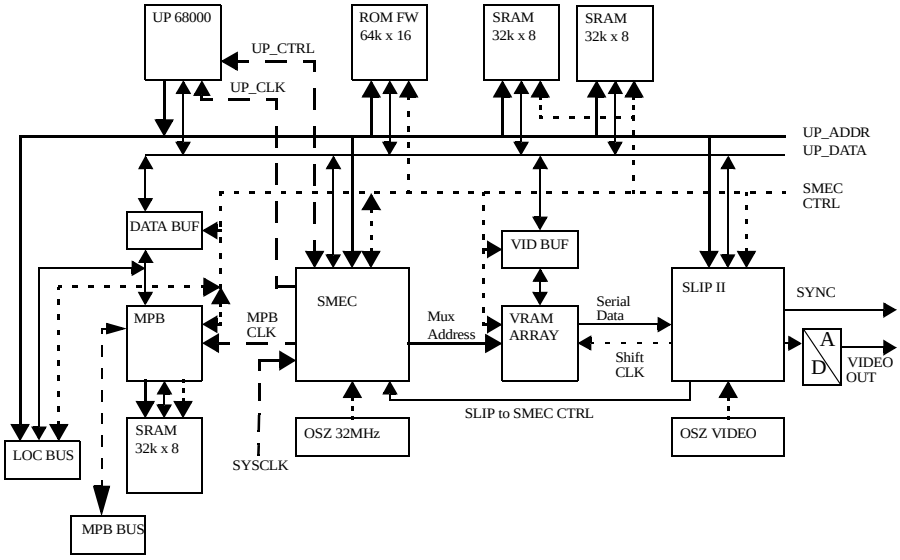


Figure 3-38 DSPC_XGA Card Block Diagram

Summary of DSPC_XGA Card Features

A summary of the features of the DSPC_XGA card follows.

- Displays up to 8 overlapping waves in 7 colors, with horizontal scrolling.
- Two alphanumeric/graphic planes (1024 x 512[1] pixels x 3 color buffers) for displaying text, figures, and simple graphics.
- One wave plane with resolution (1024 x 512[1] pixels x 3 color buffers) that can display up to 8 overlapping waves with horizontal scrolling.
- Three character sizes:
  large = 20 x 36 pixels, standard = 10 x 18 pixels, dense = 7 x 14 pixels.
- Attributes resolution 320 x 480 cells.
- Can drive a master XGA compatible display.
- Color luminance equalization.
- 60 Hz operation.

1. The resolution 1024 x 512 is made XGA compatible (1024 x 768) via repeating every second row.

Utility CPU

Introduction

The Utility CPU is responsible for interfacing to several devices and providing the synchronization and clock signals for the rest of the CMS.

Some of the interfaces connect to the MPB, others connect to the same cluster as the Utility CPU. Therefore, these interfaces are kept separate from the CPUs. The individual applications do not have to handle their own interfaces such as the SDN.

Connections or Interfaces

The Utility CPU supports a number of interfaces for the CMS. These are either on the card itself or on local cards in its cluster.

Table 3-24 Utility Card Interfaces

Location	Type	Description
On the CPU board	Philips-HIL	Used for the user inputs, integral and remote keypads, and touchscreen.
	Nurse Paging Relay	Used for connecting to a light or other alarm.
On local cards	Rack Interface	Connects to the Module Racks (maximum of 2 interfaces).
	SDN Interface	Connects to an ICU/CCU Serial Distribution Network.

Components

The Utility Card contains the following functional areas: 68000 Microprocessor, EPROM, EEPROM, CERBERUS, Output Register, Address Decoder and Dtack Logic, SRAM, Real Time Clock, Relay, HIL Rear Panel Connector, Phone Jack Rear Panel Connector (Nurse Paging), MPB Interface, FIFO, Pull Up Arrays, Reset Logic, 32 millisecond synchronizer, Main Clock, and the Local Bus buffers.

68000 Microprocessor The 68000 Microprocessor is used on the Utility CPU card.

EPROM The EPROM (capacity 64 Kbytes) contains firmware that is executed when the system is switched on.

EEPROM The EEPROM (capacity of 8 Kbytes) stores the current configuration of the system.

SRAM Non-Buffered static RAM with a capacity of 128 Kbytes.

HIL Rear Panel Connector

Philips-HIL is the Philips Human Interface Link. This is a proprietary interface for any human interface. Examples of supported devices are: Human Interface Board for the Control Panel of the Display Module, Remote Keypad, and the Touchscreen.

Phone Jack Rear Panel Connector (Nurse Paging)

The phone jack used for nurse paging is intended to give some type of alarm that is either visual, audio, or both.

This is a single-closure relay with its contacts connected to a stereo (trs) phone jack on the card edge of the Utility CPU Card.

MPB Interface

This is the interface between the card and the MPB. For more information, refer to the beginning of the Master Function Cards section.

FIFO

First In First Out buffer.

Main Clock

The main clock provides the clock signals to the rest of the CMS. The clocks provided are: 20 MHz, 16 MHz, and 10 MHz.

Local Bus buffers.

The local bus buffers are between the Local Bus and the rest of the utility card. They act as a buffer for information passing back and forth between the bus and the card.

Rack Interface

This is a high-speed, serial, Front-End Link (FE-LINK) for the connection of the Module Racks. A locally generated 78 kHz clock is also passed over this interface: (1) for power synchronization for the Plug-In Parameter Modules and (2) as an excitation frequency for the invasive pressure transducers. Also refer to the Rack Interface Card FE-LINK in the Local Function Cards section of this chapter, “Local Card Overview” on page 3-111.

SDN Interface

The digital Serial Distribution Network (SDN) connects to bedside units within an ICU/CCU environment. This allows the CMS to access all the data and status signals on the network. Refer to the SDN Interface in the Local Function Cards section for more information.

Theory of Operation

The following describes the operations of the Utility CPU card.

Interrupts

There is a support chip to encode interrupts so the processor can react to interrupts. For example, power fail (PFAIL) and external interrupt (EXINT) from the local bus.

Address Decoding

The address decoding logic is used to generate enable signals for the on-board devices, such as the MPB, SRAM, and EPROM.

Bus Error Logic

The bus error logic is a timer that watches the microprocessor's address strobe. When the processor outputs an address on its bus, it asserts the address strobe to indicate that a valid memory address is available. However, if the signal is asserted for too long, then the logic assumes that the access was not terminated correctly; that is, the address strobe was not negated or removed. The logic then asserts a Bus-Error to tell the processor that it could not access the memory correctly.

PFAIL and SYSRES

The PFAIL signal is used to inform all other function cards that a SYSRES should be expected from the Utility CPU. This is to allow the system to reset all the CPU cards synchronously. One bit of the CPU output latch is used to place PFAIL on the utility bus.

The PFAIL signal is asserted by the CPU if the CPU detects that a serious error has occurred in the system or the watchdog timer detects a failure in the CPU**.**

The PFAIL is also asserted by the DC-to-DC converter when the power is about to fail.

Real-Time Clock

There is a real-time clock chip that outputs a one-second clock to the MPB. This chip receives its power from a special capacitor when power is lost. The worst case would power the chip for 100 hours, but more typically the supply would last 255 hours, or over 10 days.

Timing Generation

The Utility CPU generates the clock signals from a 40 MHz oscillator. The oscillator output is fed to a divide-by-2 network to produce the main 20 MHz system clock. The Utility CPU provides, for internal use, the 16 MHz and 10 MHz CPU clocks and an inverted 10 MHz local clock.

An 8 MHz clock signal is produced for the Philips-HIL Chip.

A 78 kHz clock signal is sent to the Rack Interface. This clock is an excitation signal for the invasive pressure transducers and is used to synchronize the plug-in module power supplies.

Nurse Paging Relay

The Nurse Paging Relay is a single-closure relay, used to control an external device such as a light or buzzer. It is operated under software control. The contacts of the relay are connected to a stereo phone jack on the edge of the Utility CPU card.

When the relay is operated, a loop connection is closed between the tip and the ring of the phone jack. The sleeve is at ground. This allows control over an external device. For example, a lamp or buzzer and a power supply, connected through a power relay, can be used to give an alarm that is either visual, audible, or both.

WARNING

Connecting power voltages to the phone jack results in a hazard to personnel when removed.

Philips-HIL Interface

The Philips-HIL is Philips' Human Interface Link. Devices supported by this link are the keypads and touchscreen used by the Display Module.

The Philips-HIL is a serial digital link that uses a two-wire bus. The devices it connects are daisy-chained to the HIL Master on the Utility CPU card. Each device tags its data with its identity.

Before data are placed on the bus by a device, the device looks downstream to see if there are any other data on the bus. If data are present on the bus, the device adds its

own data to the end of the data stream. The data stream is interpreted by the HIL Master.

Memory Addressing Each memory location, on either the CPU card or local memory cards, is addressed absolutely using the processor's 23-bit address bus.

Data Transfers There are buffers on the processor bus to connect to the local bus of the cluster. This allows data to be passed between the processor and the local memory cards.

SDN Synchronization This is performed by the Utility CPU Card. Refer to the SDN Interface functional description in the Local Functional Cards section of this chapter,“Local Card Overview” on page 3-111.

Functional Block Diagram

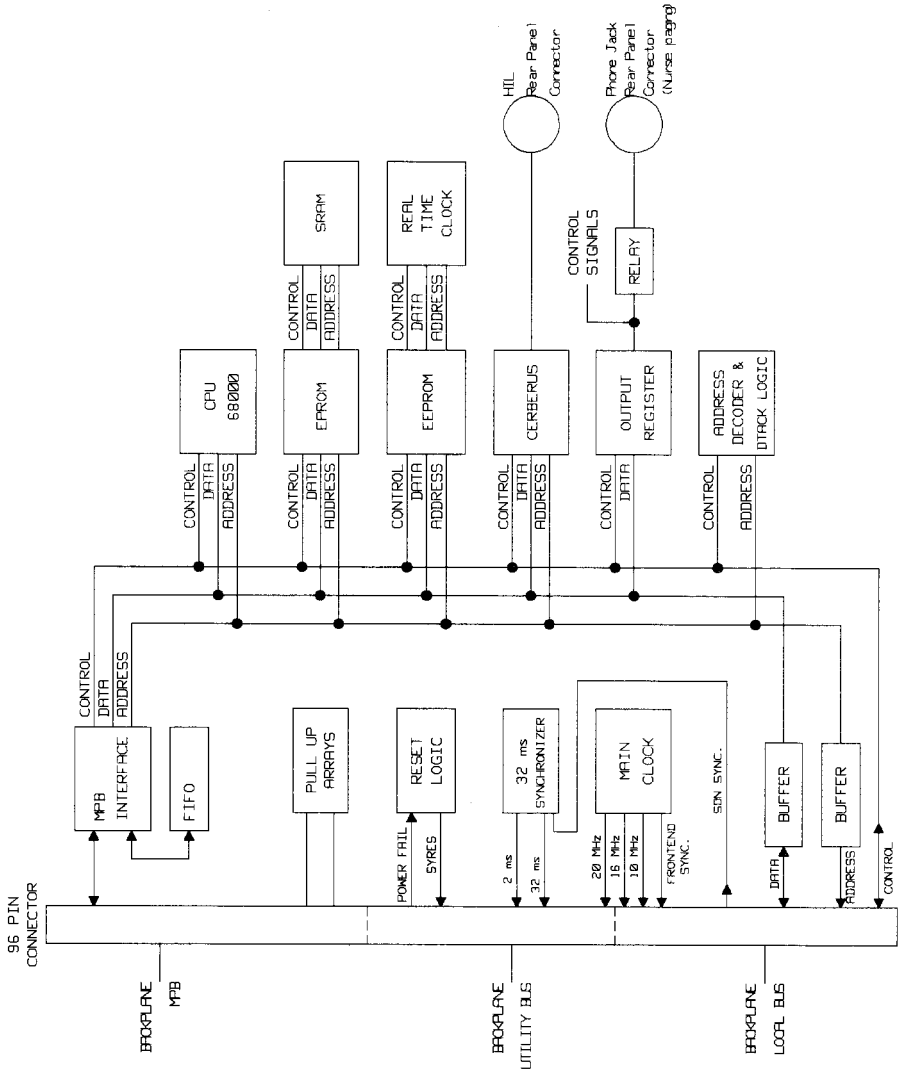


Figure 3-39 Utility Card Block Diagram

Utility Card LEDs

The utility card has six LEDs. Three of these are for error status and the other three are for the voltage. These are described in Table 3.26.

Table 3-25 Utility Card LEDs

LED	Description
1. MPB Error LED (red)	When lit, indicates there is a problem with the MPB Interface Chip.
2. Error/Status LEDs (green)	Connected to the processor through the output latch, these LEDs are under software control. They may be lit to indicate a hardware failure on the card during the boot phase when no MPB messages can be sent. When the system is running, they may reflect the status of the card.
3. Voltage Indicator LEDs (green)	Used to monitor the presence of the DC-to-DC converter voltages +12V DC, -12V DC, and +5V DC on the Utility Bus.

Summary of Utility CPU Features

The functions of the Utility CPU card are as follows.

- Real-Time Clock, buffered power supply (>100 hours).
- Nurse Paging Relay.
- System Clock.
- 32 millisecond Frame Clock
- 2 millisecond Sample Clock.
- Power-On Reset.
- Voltage indicator LEDs for +12V, -12V and +5V.
- EEPROM (8 Kbytes) for system configuration.
- Philips-HIL Master Controller.
- SDN Synchronization.
- Rack Interface with excitation signals for plug-in modules.
- Error LEDs (3).

RS232/RS422 Dual Interface Card

Introduction

The RS232/RS422 Dual Interface card is used to interface the CMS with the outside world. Computer interface communication is only possible with RS232. The interface uses the RS232 standard.

The RS422 standard is currently not available. The RS422 hardware has been included on the interface card for possible future applications.

This card connects to the MPB and is therefore, a master card. This card does not have any associated local cards. Therefore, it does not have any connection to the Local Bus. This card can be placed in any vacant slot of the CMS, even a vacant slot in another master cards's cluster.

Software Release Changes

The following is information on software releases that affect the functionality of the card.

Software Release C

With Software Release C, the card provides a computer interface that allows connection through two independent ports to a printer (for example, the HP ThinkJet and HP LaserJet series equipped with an RS232 interface) and computer system. The port is driven from firmware associated with an Application CPU or CPC card. Refer to the Computer Interface Programming Guide for further details on this capability.

Connections

The interface card is designed to be connected to equipment that has a compatible RS232 interface using one of the two 25-pin, D-type connectors.

The ability to output to computer systems using the RS232 standard can be switched on or off in the *Configuration Mode* for both ports. The differences between the ports is outlined in Table 3-26.

Table 3-26 Port Description

Port	Description
Port 2 (upper connector)	Can be used to output RS232 information to printers or computer systems.
	If you only require an output to a printer (port 2), the configuration for port 2 should be *CompOff*.
	Older models allow connection to a printer through the upper port only.
Port 1 (lower connector)	Is exclusively used as the output to computer systems.
	Does not provide an output for printers.
	Provides faster (configurable) baud rates than port 2.

Pinouts The connector is wired as a standard RS232 connector with the additional data lines used for RS422 data transmission.

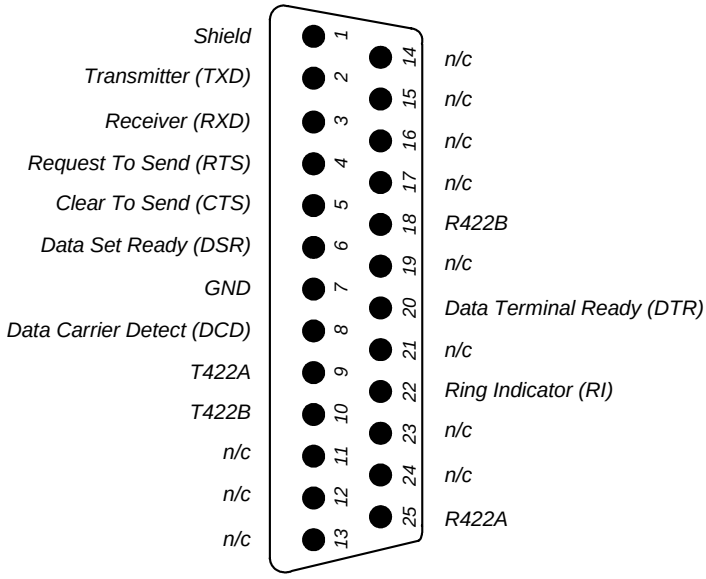


Figure 3-40 Connector Pin Signals

Components

The RS232/RS422 Dual Interface card consists of the following functional areas: MPB chip, FIFO, Micro Controller, UART, RS232/RS422 Drivers, RS232/RS422 Receivers.

MPB Interface The MPB Interface is the interface between the card and the MPB. For more information, refer to the beginning of the Master Function Cards section.

FIFO First In First Out buffer.

Microcontroller The interface uses an 8051 Microprocessor, which provides one of the serial ports.

UART This provides the second serial port on the card.

Theory of Operation

The following defines the operations of the dual interface card.

Data Transfers Data are passed between the MPB and the interface. On data being sent out of the RS232 port 1 or 2, the data are converted from parallel to serial format. On data being received from the RS232 port 1 or 2, the data are converted from serial to parallel format.

Transmission The data are loaded into the MPB Interface's RAM. The processor reads these data and writes it into the serial port register. Port 1 uses the microprocessor's internal serial port register, and port 2 uses the UART. Data are then shifted-out of the registers at the chosen baud rate. The RS232/422 drivers transform the TTL voltages into those suitable for the RS232 and RS422 transmission.

RS232 Data Reception The RS232 voltages received are converted to TTL levels. The data are written into the serial port input registers for each port and then buffered in the MPB Interface RAM before being output to the MPB. Note: the RS422 interface is not used.

RS232 Baud Rate The interface can be switched, under control of application software in the DEV_CONFIG command of the session, to accommodate a range of devices that use fixed data transmission speeds. The baud rates available for the interface are as follows: 150, 300, 600, 1200, 2400, 4800, 9600, 19200, and 38400 (port 1 only).

Functional Block Diagram

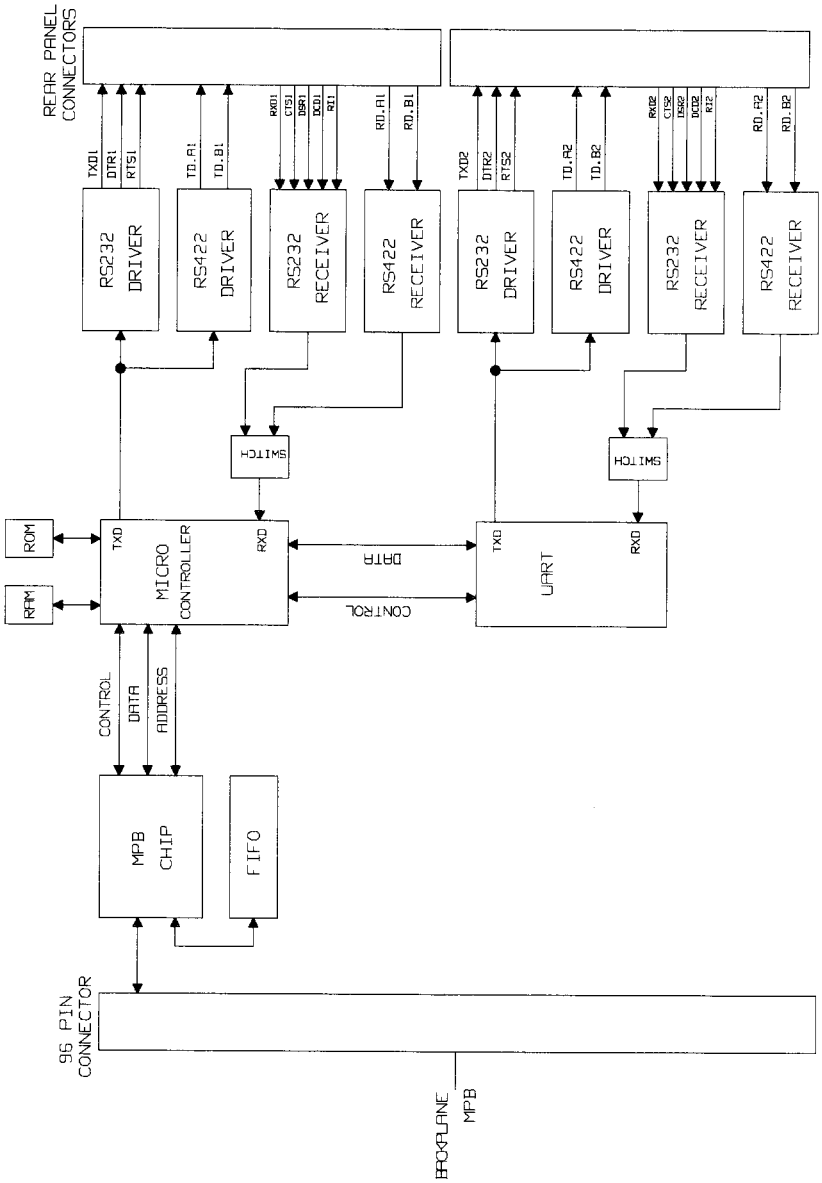


Figure 3-41 RS232/RS422 Dual Interface Card Block Diagram

Summary of RS232/ RS422 Features

The Features of the RS232/RS422 are as follows.

- Provides 2 serial ports using 8051 microprocessor with an additional UART.
- Communicates directly between external devices and the MPB.
- Translates MPB parallel data broadcast on a 16-bit bus to serial data over RS232 and RS422 standard interfaces.
- Translates received serial data from the RS232 to MPB parallel data.
- Switchable baud rate, under control of application software.

HDLC Interface Card

Introduction

The HDLC Interface card provides the Computer Module with an interface to any real-time wave recorders which use the Standard Recorder Interface Protocol (STRIP). Two recorders linked in a daisy chain can be connected to the Computer Module using this card.

The HDLC is a master card and therefore connects to the MPB. The card does not require any local cards in its cluster. Therefore, it does not have a connection to the local bus.

This card may be located in any unused slot in the computer module, even a slot that is part of another master card's cluster.

Components

The HDLC card consists of the following functional areas: MPB Interface, FIFO, HSCX, Driver, 68000 CPU, EPROM, SRAM, Test Loop Register, and Address Decoder and Dtack Logic.

MPB Interface The MPB Interface provides the interface between the MPB and the card. For more information, refer to the beginning of the Master Functional Cards section of this chapter, "Master Card Overview" on page 3-64.

FIFO First In First Out buffer.

HSCX This is the HDLC Controller. It is controlled by the CPU in interrupt mode.

68000 CPU The HDLC card contains a 68000 Microprocessor. This processor controls the operation of the card.

Theory of Operation

The HSCX can control two identical independent synchronous serial channels (A and B). These channels are built-up using transmit and receive FIFOs and control registers which can be accessed asynchronously by the processor without wait states.

Only channel B is used for the HDLC link, and it is connected to the operational port. The inverted RTS output of the HSCX controls the direction of the HDLC driver.

Data Transfer

The HDLC Interface communicates with the connected devices in a Master-Slave configuration, with the HDLC Interface as the Master.

Commands and data from the MPB are received by the CPU on the HDLC Interface. The CPU interprets the commands and rearranges the data into the format required by the HSCX and STRIP protocol. It then loads the data into the HSCX to be transmitted to the external HDLC devices.

Data received from the devices are reformatted by the CPU and transmitted via the MPB.

The CPU can also be commanded to poll the connected devices automatically every 32 milliseconds for synchronization.

CAUTION

ESD Protection. The HDLC connector shields all ESDs when a cable is not connected to the port on the HDLC link. However, ESDs into the unconnected end of an HDLC cable, which is connected to the HDLC Interface on the Computer Module, will result in driver damage. Always disconnect the HDLC cable at the Computer Module end when other equipment is not attached to the cable.

WARNING

Ground Safety Connection. There is no signal ground connection on the HDLC cable to STRIP devices; the cable shield is only connected at one end of the cable. For this reason, the signal ground and safety ground in each HDLC device must be tied together. Additionally, there must be a connection between the safety ground of all devices and the power cord safety ground or additional grounding cables.

Testing/Diagnostics

Testing/Diagnostics available on the HDLC card are detailed in the following.

Loop Tests

An internal loop test checks HSCX operation. The HDLC drivers are tested by an HSCX external loop, which can be opened or closed by resetting/setting the test loop register.

Functional Block Diagram

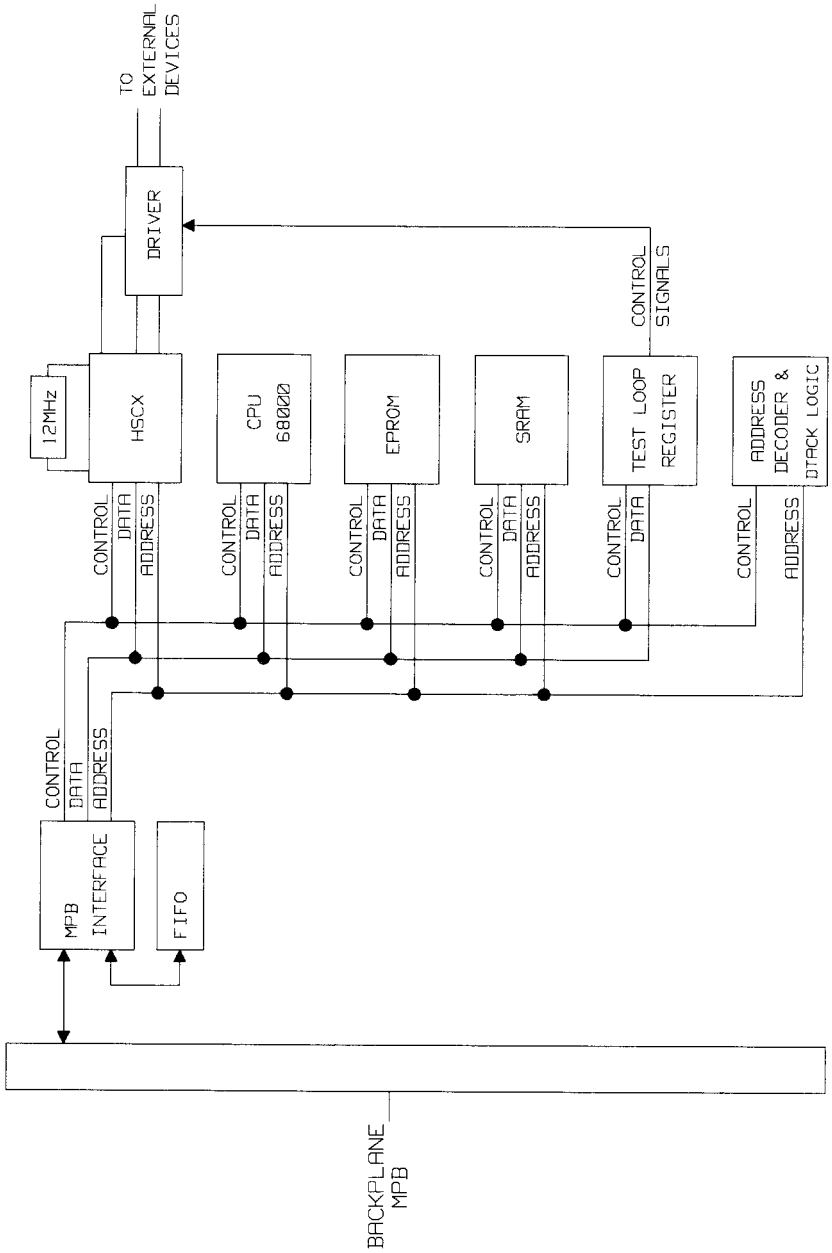


Figure 3-42 HDLC Interface Card Block Diagram

Summary of HDLC Features

The features of the HDLC card are detailed in the following.

- Provides an interface to real-time wave recorders.

- Performs internal tests to check the operation of the controller and drivers.
- Controls a maximum of two devices in daisy chain.
- Receives commands and data via the MPB.
- Formats the data to HSCX and STRIP protocol, then transmits to connected devices.
- Receives data from devices, which it then transmits over the MPB.

Analog Interface Card

Introduction

The Analog Interface card provides the Computer Module with eight channels of analog output, which can be connected to recorders and other data collection instruments.

This card is a master card, but it does not require any connections to the Local Bus, as there are no dependent local cards required for its operation. Therefore, it may be located in any vacant slot in the Computer Module, even a slot that is part of another master card's cluster.

Both wave and numeric outputs are available; channels can be controlled individually with respect to wave or numeric display and gain and offset control. In addition, eight alarm/INOP status lines are provided as digital outputs, which can be used to trigger alarm recorders or other data collection instruments.

Components

The Analog Interface card consists of the following functional areas: MPB Chip, FIFO, Micro Controller, Multiplying DAC, Error Measurement Unit, Gain Error Compensation DAC, Sample and Hold Register, Sample and Hold Circuits, Low Pass Filters, and Digital Port.

MPB Interface The MPB interface provides the interface between the MPB and the card. For more information, refer to the beginning of the Master Function Cards section of this chapter.

FIFO First In First Out buffer.

Microcontroller The microprocessor used on the Analog Interface card is the 8051.

Multiplying DAC This is one of the two digital-to-analog converters (DACs) that provide eight analog output channels.

Gain Error Compensation DAC This is one of the two DACs that provide eight analog output channels.

Digital Port The Digital Port is an 8-bit port.

Theory of Operation

The operations of the Analog Interface card are defined in the following.

Absolute Wave Handling When switching the scale or size of an absolute wave, the analog output may be affected for up to two seconds. This is due to the internal handling of scaled waves by the CMS.

Noise The Analog Interface has grounded inputs. Ground loops in the installation (through grounded inputs at the receiving device) may introduce additional noise to the analog signals. Lowest noise is obtained when the external analog device is connected with floating inputs or to devices with differential inputs.

Remote Installations When the Display Module is installed remotely from the Computer Module, the analog interface ground (digital and analog ground) shows a DC voltage with respect to safety ground (approximately 3 mV/m of cable length between the Computer Module and the Display Module). When connecting the Analog Interface to devices with grounded inputs, this voltage leads to an additional offset error at the inputs of the connected devices. The offset can be compensated for, either at the connected device or by adjusting the offset for the analog channels. The offset can be avoided by connecting the Analog Interface to devices with floating or differential inputs.

Output Delay The waves available from the Analog Interface are filtered and processed by the parameter-specific algorithms in the CMS. The processing delay from parameter input to analog output is approximately 250 milliseconds. This delay is constant for each channel and between channels.

WARNING

Do not synchronize balloon pumps or defibrillators using the Analog Interface on the CMS. An output delay of approximately 250 milliseconds is present on the signal's output from the Analog Interface.

Digital Output The digital output port comprises an eight-bit register with ESD and short-circuit protection. The low output impedance of the port guarantees proper TTL output levels for up to 1.6 mA output current.

Analog System The analog system consists mainly of a 12-bit multiplying DAC, a precision +5V reference, an error compensation loop, and eight analog channels.

Digital-to-Analog Conversion

The +5V reference signal is input to the 12-bit multiplying DAC to regulate the DAC output. A second (8-bit) DAC unit provides gain error correction of the conversion process.

Error Compensation Loop

Continuous error compensation is used to improve analog accuracy by compensating for component tolerances and drift. Gain and offset error are measured by the error measurement unit, while all sample and hold circuits are switched to *Hold*. Firmware adjusts the values for offset correction and the Gain Error Correction DAC accordingly.

Analog Channels

Each analog channel is built up by sample and hold circuits and a low-pass filter. The ground for the analog circuit is derived from the Computer Module's digital ground, which, in turn, is connected to the safety ground in the Display Module.

Analog Interface Output Connector

The signals available on the Analog Interface output connector are shown below:

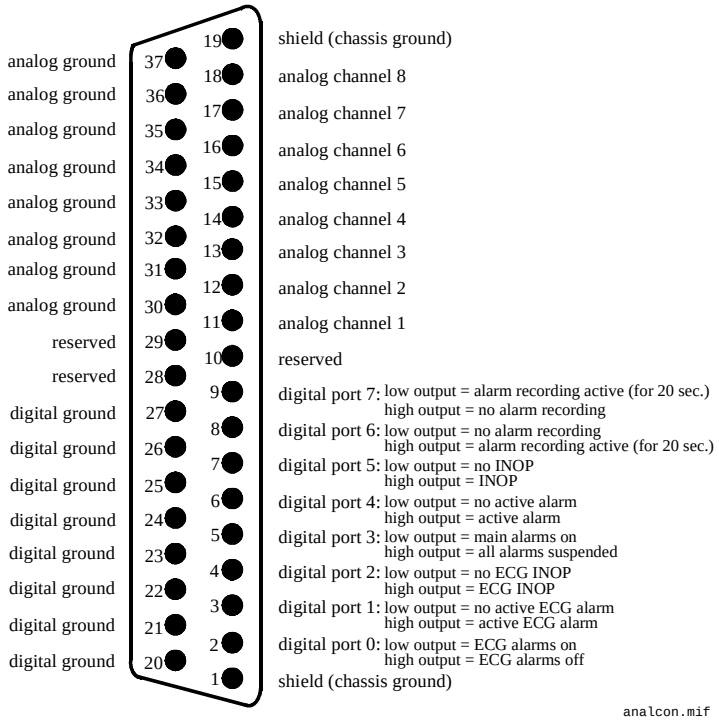

analog ground 37
analog ground 36
analog ground 35
analog ground 34
analog ground 33
analog ground 32
analog ground 31
analog ground 30
reserved 29
reserved 28
digital ground 27
digital ground 26
digital ground 25
digital ground 24
digital ground 23
digital ground 22
digital ground 21
digital ground 20
19 shield (chassis ground)
18 analog channel 8
17 analog channel 7
16 analog channel 6
15 analog channel 5
14 analog channel 4
13 analog channel 3
12 analog channel 2
11 analog channel 1
10 reserved
9 digital port 7: low output = alarm recording active (for 20 sec.) high output = no alarm recording
8 digital port 6: low output = no alarm recording high output = alarm recording active (for 20 sec.)
7 digital port 5: low output = no INOP high output = INOP
6 digital port 4: low output = no active alarm high output = active alarm
5 digital port 3: low output = main alarms on high output = all alarms suspended
4 digital port 2: low output = no ECG INOP high output = ECG INOP
3 digital port 1: low output = no active ECG alarm high output = active ECG alarm
2 digital port 0: low output = ECG alarms on high output = ECG alarms off
1 shield (chassis ground)
analcon.mif

Figure 3-43 Analog Interface Output Connector

Functional Block Diagram

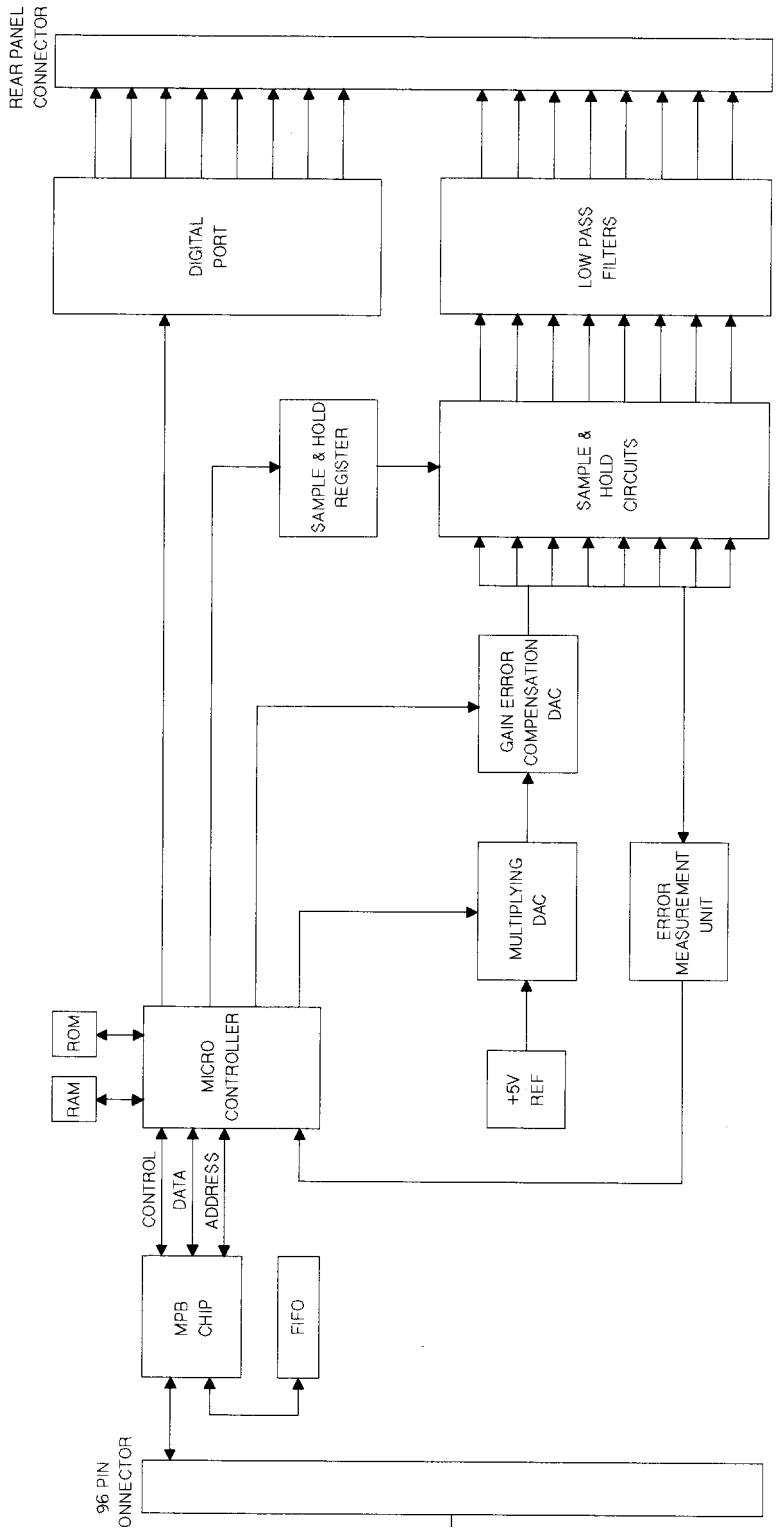


Figure 3-44 Analog Interface Card Block Diagram

Summary of Analog Card Features

The features of the Analog Interface card are as follows.

- Provides an interface to devices with analog inputs needing real-time waves or slowly changing trend data.
- Provides eight digital alarm/INOP status lines to trigger alarm recorders or other data collection instruments.
- Provides eight analog signals, output on a 37-pin connector.
- Incorporates an error compensation loop to compensate for component tolerances and component drift.

CMS Local Function Cards

Introduction

This section provides detailed information on the local function cards contained in the Computer Module of the CMS. The information includes connections, theory of operation, functional block diagrams, and testing information.

Information on master function cards is contained in another section.

Refer to the Computer Module description in the CMS Modules section for details on card configurations.

Objectives

After successfully completing this module, you should be able to:

- Identify the local function cards used by the CMS.
- Identify the master cards they support.
- Describe the function and operations of each card.

Concepts

The following concepts are important to the operation of local function cards.

Local Card Identifier -- A mechanism that identifies the type of card in a cluster and its position. It may also be used to test the compatibility of the local card with the master card in the cluster. The identifier is hardwired onto the card, and contains the board type, hardware revision, and version.

EPROM -- Erasable Programmable Read Only Memory. This type of memory is used on local cards to store executable code and data for master cards. The EPROM card stores operating and application software for Application CPU cards. The Display Language EPROM card stores language-dependent display characteristics.

Front-End Link -- A high-speed serial communications link used by the Rack Interface card to transfer data between the Computer Module and the Module Racks. The CMS receives a patient's measurement data from the plug-in modules over this link.

Polling -- A mechanism by which a communications device identifies the presence, location, and identities of connected devices, and whether they have data to transfer. The Rack Interface card polls the Plug-In Parameter Modules over the Front-End Link. The modules place data onto the link in response to being polled.

SRAM -- Static Random-Access Memory. This type of memory is used on local cards to store data for a master card before and after processing. The type of data stored depends on the application software used.

SDN Synchronization -- The timing method used to synchronize the SDN Interface with the Utility CPU. A 32 millisecond frame interrupt on the SDN interface is synchronized with the SDN synchronization signal on the Utility CPU. The utility card's signal is used to indicate the start of a poll cycle for data transfer.

Topics

This section contains the following topics.

Table 3-27 Topics in this Section

Topic	Page
"Local Card Overview"	3-111
"EPROM"	3-113
"SRAM"	3-115
"Color Display Video Card"	3-118
"Serial Distribution Network Interface"	3-122
"Rack Interface"	3-126
"Aux Connector Card"	3-129
"Remote Switch Card"	3-129

Local Card Overview

Introduction

The CMS contains two types of function card: master cards and local cards. Master cards have a microprocessor and connect to the Message Passing Bus (MPB); most also have a connection to the Local Bus. Local cards perform supporting functions for the master cards and connect to only the Local Bus. Master cards communicate with the system over the MPB, and with their corresponding local cards over the Local Bus.

Refer to CMS Bus Structure in the System Overview section for a description of the bus architecture.

Local Card Functions

The local cards do not interface with the MPB bus; rather, they connect to the Local Bus. A local card is never used alone in a cluster; there is always a master card in a cluster.

Table 3-28 Local Cards

Card Name	Function
EPROM EPROM	Pre-Release C Software: Contains software used by a master CPU card. For example, in the case of an Application CPU, the EPROM card would contain the application software. Post-Release C Software: The application software is integrated into the CPU card.
Display Language EPROM DSPC-LANG	An EPROM card that is used to store the Asian characters used by the Japanese, Chinese and Taiwanese systems. These characters require more memory capacity than is available on the display controller's ROM.
Static RAM SRAM	Used to hold data before and after processing.
Color Video Card CDSPC-VIDEO	Contains the pixel Video RAM for the color display. Used in CMS, delivered prior to Release G.
Serial Distribution Network Interface SDN-IF	Used to acquire serial data, messages, and alarms from the SDN. Messages and data may also be broadcast back onto the SDN for use by bedside monitors, arrhythmia computers, or the System Communications Controller (SCC) at the hub of the SDN star network.
Rack Interface RACK-IF	Provides access to the Module Racks.
Auxiliary Connector AUX_CONNECTOR	**M1046B Only:** Provides access to the Rack Interface behind the Computer Modules integral power supply.
Remote Switch REMOTE_SWITCH	**M1046B Only:** Provides connection and the remote switching of the DC power to the computer module, the module racks and the flatscreen display.

Local Card Identifier

With the exception of the SDN card, local cards can generally be used any number of times in a CMS or in a particular cluster. Each local card has a unique identifier used to specify the type of card and its position in the cluster. This identifier contains the board type, hardware revision, and the version. The identifier may also be used to test the compatibility of the local card with the master card.

When a master card requests the identifier, it is placed on the Local Bus by selecting that card (done by the comparator matching the high address bits along with the slot number) and at the same time sending an Access Identifier (ACC) to the card.

On the local card, the identifier information is hardwired onto the card by using a pair of octal bus drivers. The output of the drivers is connected to five lines on the Local Bus.

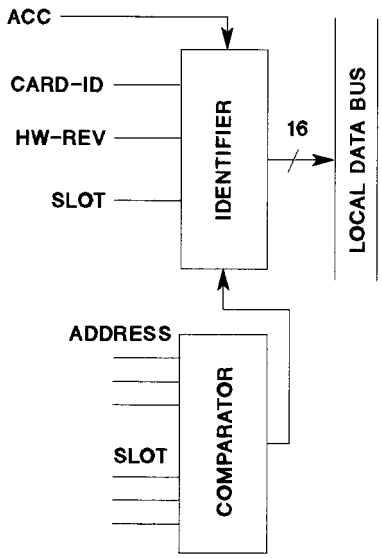


Figure 3-45 Local Card Identifier

EPROM

Introduction

The EPROM card is a local card that connects to the Local Bus. It is used by a master card such as the Application CPU to store executable code of the application software and the operating system. It may also be used by a display controller (DSPC or CDSPC) for language-dependent display characters.

Components

The EPROM card consists of the following functional areas: Data and Address Buffers, Identifier, EPROM, Address Decoder, and Timing Control.

Data and Address Buffers The EPROM has its internal data and address buses buffered at the connection to the local bus.

Identifier The identifier contains information that allows the CPU in the cluster to identify that this is an EPROM card.

EPROM The EPROM is a memory array of up to 1.28 Mbytes in steps of 256 Kbytes. The EPROM card holds the data in two chips. One chip holds the higher byte of the 16-bit word, and the other chip holds the lower byte of the 16-bit word.

Address Decoder The address is decoded and sent to the EPROM to allow the data at the specified address to be accessed.

Theory of Operation

At start-up, the CPU in the cluster looks at all the slots in its local cluster and identifies the local cards and their location. If an EPROM card is detected, the CPU jumps to the code area of this card and begins executing the code.

Any problem with the EPROM card is handled by the master card. This board does not have any on-board tests or error LEDs.

Programming There are no removable devices on the card. When the software is updated or changed, the card is programmed as a whole.

Functional Block Diagram

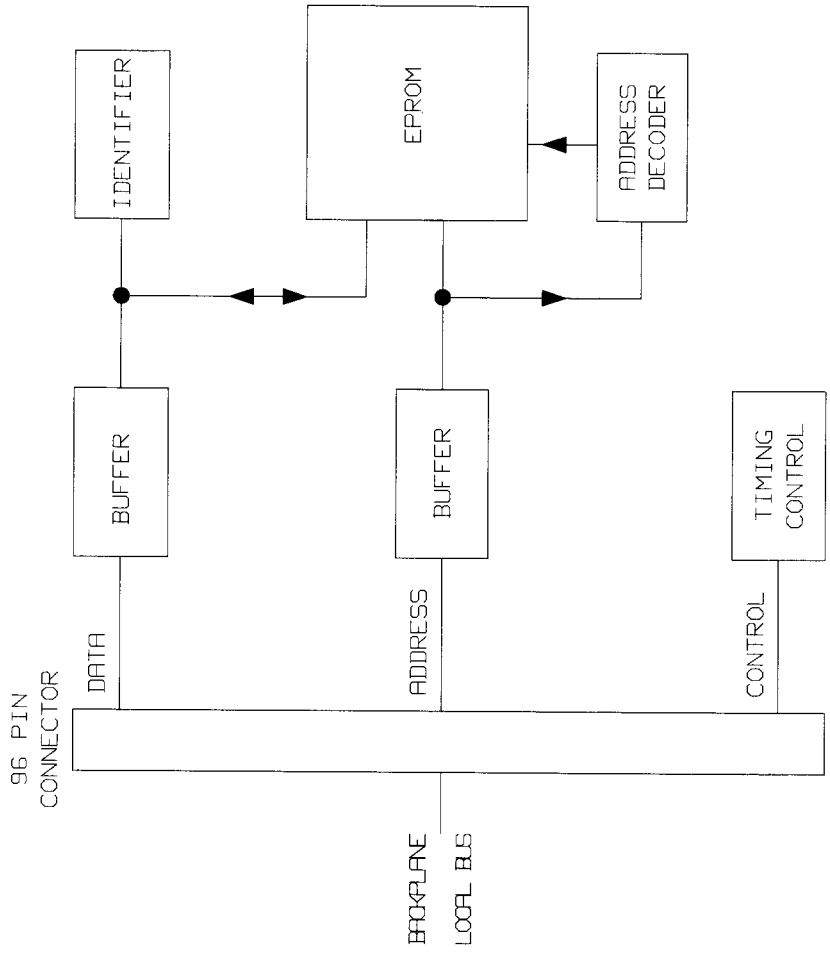


Figure 3-46 EPROM Card Block Diagram

Summary of EPROM Features

The features of the EPROM Card are as follows.

- Large memory array (256 Kbytes steps up to 1.28 MB).
- Contains the complete application software / operating system.
- Card programming allows easy exchange or upgrade of software.
- Label for software part number.
- 0 or 1 wait state options.
- Automatic execution of the software when the system is started.

SRAM

Introduction

The SRAM card is a local card connected to the local bus. It is used by a master card, such as the Application CPU, to store data both before and after processing. The SRAM contains a buffered static RAM array with a data retention time of up to three days.

The type of data stored on the SRAM card is dependent on the software. For example, data management software may store trends and numeric data as well as other processed results.

Components

The SRAM card consists of the following functional areas: Data and Address Buffers, Address Decoder, Address Input Circuit, Timing Control, Identifier, SRAM, and Back-up Power Supply.

Data and Address Buffers The data and address buffers are used to buffer the data between the local bus and the SRAM card.

Address Decoder The address decoder is used to specify the address of the data in the SRAM that is either to be written or read.

Identifier The identifier is used by the CPU in the cluster during start-up to identify this card.

Back-Up Power Supply The back-up power supply is a two-cell Nickel-Cadium battery that provides power to the SRAM in the event of a power failure.

Theory of Operation

The following describes the operations of the SRAM card.

Data Transfer Data are is transferred between the master card and the RAM array using the Local Bus. The data are is placed on a 16-bit data bus, and the address is placed on a 23-bit address bus, along with some control lines.

Switch to Back-Up Power

When a power loss is sensed, the System Reset signal (SYSRES) SYRES) locks the RAM from further access. This prevents any access to the SRAM and keeps the contents from being corrupted.

The switch from the DC-to-DC converter to the battery is made when both the supplies deliver the same voltage.

Data Retention Time

The ratio of the data retention battery charging time to the battery charging to the data retention time is a minimum of 2.5. For example, if the battery is charged for three hours, the data would be retained 7.5 hours.

Back-Up Power Supply

The back-up power supply is a two-cell Nickel-Cadmium battery with some switch logic to switch from the DC-to-DC converter power to the back-up supply.

There are two test points for measuring the battery voltages. They are TP1= Battery Voltage and TP2= Supply Voltage of the RAM array.

Over-Discharge Protection

The back-up supply has a circuit to protect the battery from being over-discharged. This prolongs the useful life of the battery.

Functional Block Diagram

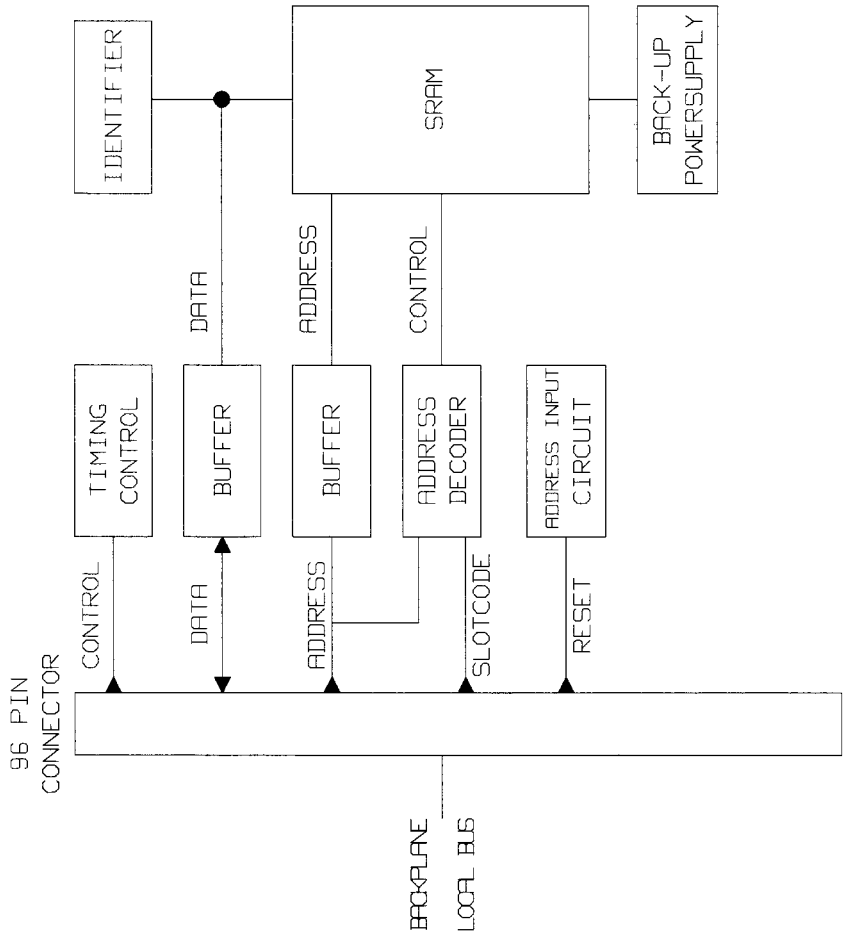


Figure 3-47 SRAM Card Block Diagram

Summary of SRAM Features

The features of the SRAM card are as follows:

- 320K word capacity.
- Loadable in steps of 32Kwords.
- Buffered RAM, using 2-cell Nickel-Cadmium battery.
- Back-up Retention Time is minimally 2.5 times the charging time. A fully-charged battery retains the data for at least three days.
- Battery over-discharge protection for improved long-term reliability.
- No-wait-state operation allows use of a 10 MHz or 15 MHz Application CPU.

Color Display Video Card

Introduction

The Color Display Controller (CDSPC) cards are a set of two cards used by the system to output display data to a color monitor. The CDSPC_VIDEO card is a local card that supports the CDSPC_CTRL card. The video card contains the Video RAM and output circuits to the Display Module. The video card is connected to its master card by the Local Bus.

Connections

Both cards must be placed in the same cluster in the Computer Module. The CDSPC_VIDEO card must be inserted into the rear of the Computer Module so that it can be connected to the display. It is connected with a cable between the 9-pin D-type connector on the card edge and a similar connector on the rear of the display. The video output on the rear of the display may be used to connect a remote display.

If Kanji characters are to be supported, the DSPC_KANJI card must also be inserted into the same cluster as the two CDSPC cards.

Each pair of CDSPC cards supports either one master display and three remote displays or four remote displays. If the system is required to produce two different color displays, a second pair of CDSPC cards must be used in a separate cluster.

For details on the components and operations of the CSDPC_CTRL card, refer to the Master Functional Cards section of this chapter, “Master Card Overview” on page 3-64.

CDSPC_VIDEO Components

The CDSPC-Video card consists of the following functional areas: Color Register, Buffer, Horizontal Wave Scroll Logic, Video System Controller, Attributes, Oscillator, Video Buffers, Color Mapping Circuit, Protection Network, and the Color Planes.

Color Register

The color register chooses the color.

Video System Controller

The three color banks of the Video RAM are controlled by the Video Controller chip.

Video RAM

The video RAM has four parts as shown in the following table.

Table 3-29 Video RAM Components

Pane/Map	Description
Alphanumerics / Graphics plane 1	(1024 x 512 pixels x 3 color banks) The two alphanumeric / graphics planes are used to display text, figures, and basic graphics (lines, boxes etc.).
Alphanumerics / Graphics plane 2	
Wave Plane	(2048 x 512 pixels x 3 color banks) The higher resolution wave plane is used for displaying the parameter waves, such as ECG.
Attribute Map	(256 x 256 bytes) The attribute map is used to enable parts of the screen and select between full-brightness, half-brightness, and blinking.

Theory of Operation

The CDSPC controller card acts as an interface between the system and the video card. The video card connects the Computer Module to the display.

The CDSPC cards only control the mechanism of actually displaying information on the screen. All display data, including local language characters and color information, are produced by the Application CPUs or CPCs. More than one CPU may produce data for the display.

Wave Plane

The wave plane displays up to eight overlapping parameter waves. This plane is implemented in a different way than for the other planes, because the wave plane must display waves that scroll horizontally on the screen. The scrolling logic moves a pointer, indicating the left of the screen, through the Video RAM, and new data are written directly behind it. This has the result of adding new data onto the right of the screen as old data are displaced on the left.

Data Transfer

The CDSPC controller card receives display data, waves, lines, numerics, display attribute data, and control messages from the CPU over the MPB. The microprocessor on the controller card sends the data over the Local Bus to the video card. The Video System Controller on the video card places the data into the dual-ported Video RAM. Display attributes, such as half-brightness, are also placed in the Video RAM.

The pixel data are clocked out of the Video RAM by the on-chip shift registers. These data then pass through the SLIP Chip, which contains all the video and addressing logic, before passing it to the video buffers. The data then pass through the protection network for output to the display. An oscillator is used to synchronize the picture sweep.

Color Equalization

The seven colors produced by the color display have their intensities equalized, so that they appear similar in intensity to the human eye. This is done by using a resistor network in combination with some transistors; red and green are added to lighten the

output of the blue output on the display. The red output has a slightly higher full intensity voltage to get brighter alarms.

Character Sets

The Japanese, Taiwanese, and Chinese character sets are too large to be stored on the standard EPROM cards. These characters are therefore stored on a dedicated EPROM card, the DSPC Language card, which is placed in the same cluster as the display controller cards.

CDSPC_VIDEO Functional Block Diagram

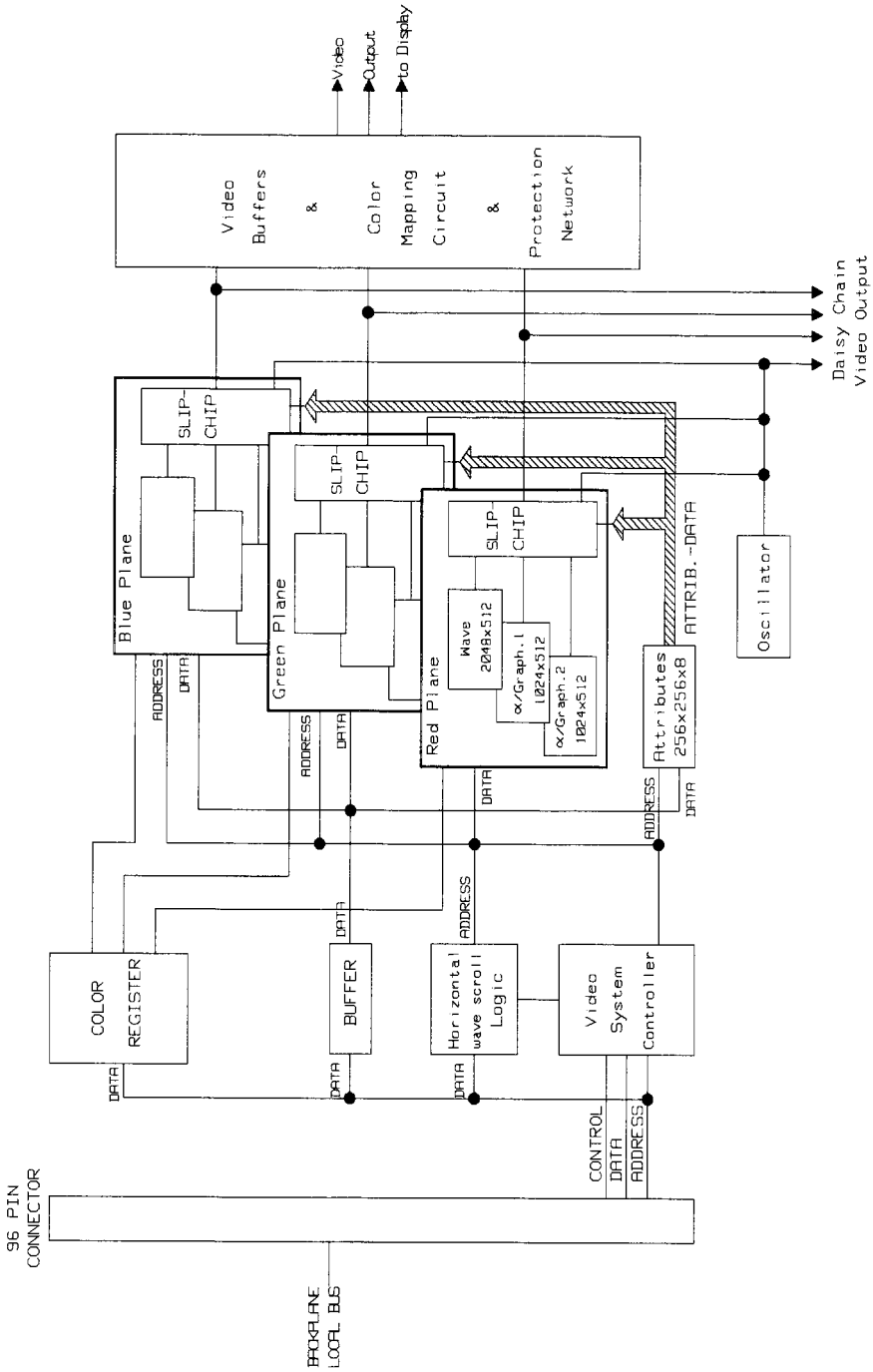


Figure 3-48 CDSPC-Video Card Block Diagram

Summary of CDSPC Cards Features

A summary of the features of the CDSPC cards follows.

- Displays up to 8 overlapping waves in 7 colors, with horizontal scrolling.
- Two alphanumeric/graphic planes (1024 x 512 pixels x 3 color banks) for display text, figures, and simple graphics.
- One wave plane with extended resolution (2048 x 512 pixels x 3 color banks) that can display up to 8 overlapping waves with horizontal scrolling.
- Three character sizes: large = 32 x 40 pixels, normal = 16 x 20 pixels, dense = 12 x 16 pixels.
- Attributes resolution 256 x 256 bytes.
- Can drive a master and up to 3 remote displays.
- Color luminance equalization.
- 60 Hz operation.

Serial Distribution Network Interface

Introduction

The Serial Distribution Network Interface (SDN_IF) card is used to interface the CMS to the SDN. The interface path is through the Utility CPU.

This card transmits data to the SDN and receives data from the SDN. Only one SDN Interface card may be used with each CMS.

Connections

The SDN interface card must be connected to a free branch of the SDN. In the event of an SDN failure or the branch becoming disconnected from the SDN, the instruments on the same branch can still communicate with each other using the autopoll circuitry in the SIC Chip, along with the priority wire. The last-box-detection circuitry checks for a downstream connection. If there is no downstream connection, the line is terminated using a relay.

Serial Distribution Network (SDN)

The SDN is a serial digital network for communications between bedside monitors and central stations, such as arrhythmia computers. The data are passed over a two-wire bus. Each data type has its own associated *signature*, similar to the way that the MPB messages have a header that identifies the information. This allows the data to be available to any device that requires it. In addition, devices do not need to know which other devices require the data. Any devices that require the information from the SDN, including the CMS, can choose the data it requires using the data signature.

All communications within the SDN are controlled by the System Communications Controller (SCC). This card is located at the center of the SDN star configuration. The SCC uses a 32 millisecond poll cycle to send instructions to the monitors on the SDN branches it controls. The poll cycle is divided into 4 milliseconds of dead time and 28 milliseconds for transferring data.

Components

The SDN card consists of the following functional areas: Address and Data Buffer, Comparator, Identifier, MUX, SIC RAM, SIGN RAM, SIC Chip, Data Sync, Last-Box Detection, Oscillator, and SDN Transceiver.

Theory of Operation

The operations of the SDN Interface card are defined in the following.

SDN Synchronization

System timing is governed by the 32 millisecond frame interrupt (Frame_Int). When an SDN Interface card is installed, the Frame_Int signal must be synchronized to the SDN_Sync signal on the Utility CPU. The SDN_Sync signal indicates the start of a 32 millisecond poll cycle for data transfer. Data can only be written to or read from the SIC RAM when both the Frame_SYNC and SDN_SYNC signals are low, during the 4 millisecond dead time.

If there is no SDN Interface card installed, then the 32 millisecond clock in the system is free-running.

Data Transfer

All data for transmission on the SDN are placed into the SIC RAM by the Utility CPU in the 4 millisecond dead time. The SIC Chip then automatically sends the data over the SDN during the 28 millisecond period. Wait cycle logic guarantees the timing between the Utility CPU and the SIC Chip.

The Utility CPU can select SDN data by placing a signature for selected data in the SIGN_RAM. Received data are placed in the other half of the SIC RAM and can be read by the Utility CPU in the 4 millisecond part of the poll cycle. A clock, using a 28.8 MHz oscillator, is generated by the DATA_SYNC gate array, and is used to synchronize incoming data. This gate array is then used to guarantee that the sample clock is in the middle of the data clock when the data are stable.

DTCK is used to acknowledge a RAM_ACCESS command from the Utility CPU, so the Utility CPU does not have to wait. Wait states are not necessary for access to the SIC_RAM, Identifier, and the 4-bit Latch.

The Utility CPU uses a 4-bit latch to perform certain operations, which are defined in the following table.

Table 3-30 4-Bit Latch

Bit	Definition
bit 0 (databit8)	Switches the control signals between the Utility CPU and the SIC Chip.
bit 1 (databit9)	Used to reset the SIC Chip. Sometimes it is necessary to reset the SIC Chip and not the whole system.

Table 3-30 4-Bit Latch

Bit	Definition
bit 2 (databit10)	Used to disable the Multiplexer before control of the SIC RAM is passed between the Utility CPU and the SIC Chip, and then to enable it after the switch. This suppresses spikes and protects the contents of the SIC RAM.
bit 3 (databit11)	Used to switch on the error LED while tests are performed on the SDN interface card. When all tests are successfully completed, the error LED is switched off.

Summary of SDN Features

The features of the SDN Interface are as follows.

- Translates the MPB parallel data that were broadcast on an 8-bit bus to serial SDN data broadcast on a two-wire bus.
- Receives all SDN messages, alarms, and data (parameters and waves).
- Transmits wave and parameter data acquired by the CMS over the SDN. For example, an ECG wave acquired by the CMS may be sent to an arrhythmia computer which adds annotated notes to the wave. Then the output from the computer can be relayed back to the CMS for display under application software control.
- Synchronizes the system frame interrupt with the SDN poll cycle (performed by the Utility CPU card).
- Detects primary bedside unit mode, either SDN or *Auto-poll*, and terminates the line as necessary.
- Controls transmit data from the primary bed unit and another instrument; for example, a local recorder using a priority wire.
- Data can be selectively acquired, with no CPU intervention, by placing *tune* headers in the SIGN RAM of the SIC Chip.
- Incoming data synchronized using 28.8 MHz oscillator.
- SIC RAM consists of two 2 Kbyte buffers (1 transmit, 1 receive).
- Latch controls, error LED, SIC Chip reset, multiplexer switch, and multiplexer disable/enable.

Functional Block Diagram

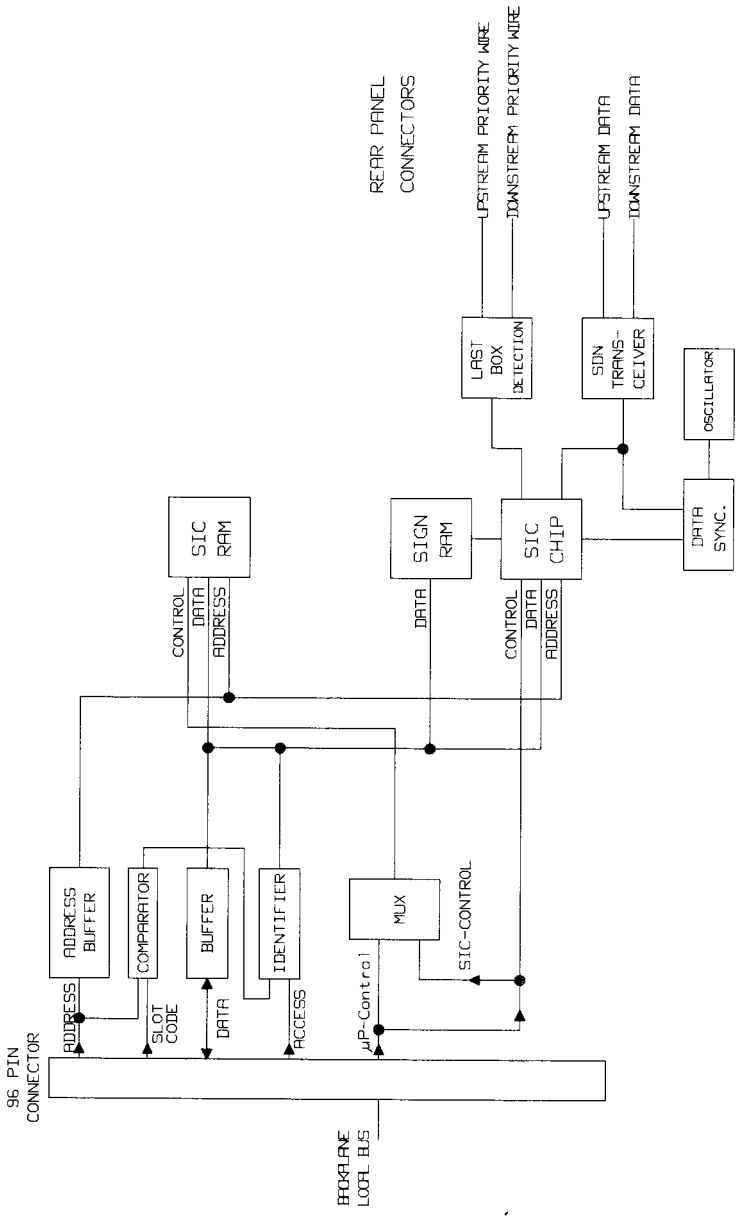


Figure 3-49 SDN Interface Card Block Diagram

Rack Interface

Introduction

The Rack Interface (RACK_IF) card supports the Front-End Link protocol (front end mode) for communications between the system and the Module Racks, which house up to 32 Plug-In Parameter Modules. Communication is through the Utility CPU.

The function of the card is to acquire data and status from the plug-in modules in the racks and send back control signals. It does this using the Front End high-speed serial link (FE-LINK). One FE-LINK can support 32 plug-in modules, which can be located in the internal rack and up to three remote or satellite racks.

The Rack Interface card also does the following: (1) routes an *ECG sync* signal to a phone jack on the internal rack, (2) routes the power from the DC-to-DC converter to all the racks, and (3) provides a special tool protocol (tool mode) for communication with external RS232 devices.

The RS232 protocol is NOT provided by this card. Any communication with RS232 devices is routed through a level converter.

FE-LINK

The FE-LINK is a high-speed (500 kilobaud) serial link for passing digital data, status, and control between the parameter modules and the Rack Interface card.

Connections

The Rack Interface card must be placed in slot 18 on the front of the Computer Module. This ensures that when the rack is mounted on the front of the Computer Module, the 20-pin connector on the back of the internal rack aligns with the connector on the edge of the interface card.

Components

The Rack Interface card consists of the following areas: Comparator, Identifier, Buffer, Multiplexer Control, Switched RAM, Address Latch, Processor, Line Driver, and LineDriver/Receiver.

Theory of Operation

The operations of the Rack Interface card are detailed in the following.

Polling

The plug-in modules place their data onto the FE-LINK in response to a poll from the Rack Interface card. The module IDs are placed into a *Scan Table* when the system is first switched on. This scan table is used to decide when to poll each module. A scan table entry consists of a complete description of the module to be polled, including ID, rack address, and number of bytes to receive and transmit. The modules are polled at different rates; for example, the ECG is polled every two milliseconds, while others such as TEMP or PRESS are polled every eight milliseconds.

Defibrillator Sync-Out

One of the three ECG waves, which are sampled every two milliseconds, is selected for input to a digital-to-analog converter. The analog output from the converter is sent with a delay of less than 20 milliseconds to the phone jack on the front of the internal rack. This analog signal is used to synchronize the firing of a defibrillator.

Marker Input

The marker input is an analog signal applied to the same phone jack for the duration of the defibrillator firing. This signal is sensed by the on-board microcontroller, and merged with the upper part of the ECG wave sample. This allows the defibrillator firing to be displayed on the screen.

DC-to-DC Power

The 60V supply from the DC-to-DC converter is placed on all the rack connectors to supply power to all the racks via the FE-LINK cables.

Data Transfer

The method for data transfer used by the Rack Interface is called *RAM Multiplexing*. Two RAMs are used alternately by the on-board 8051 Microprocessor and the 68000 on the Utility CPU. Every 32 milliseconds the RAMs are switched, using the 32 millisecond frame-interrupt from the Utility CPU, so the RAMs can be accessed by the other processor. This allows the faster 68000 processor to exchange data with the RAM and then run-on before the RAMs are switched.

The on-board 8051 Microprocessor then converts the data into serial data for passing to the racks over the FE-LINK, with no further intervention by the Utility CPU.

Serial data received from the plug-in modules through the FE-LINK is converted to parallel data and placed into the RAM by the on-board 8051. The RAMs are then switched, allowing the Utility CPU to exchange data again.

System Turn On

When the system is first switched on, the interface card polls the racks to identify the parameter modules that are plugged into the racks.

Summary of Rack Interface Features

The features of the Rack Interface card are as follows:

- Translates serial parameter data from the FE-LINK to parallel data for transmission to the Utility CPU over the 8-bit local bus.
- Translates parallel data from the 8-bit local bus to serial data for transmission over the FE-LINK.
- RAM multiplexing eliminates intervention of the Utility CPU during data transfer.
- Routes the power from the DC-to-DC converter to the internal and satellite racks.
- Digital-to-analog converter produces a sync output for defibrillator firing and senses a marker pulse.

Functional Block Diagram

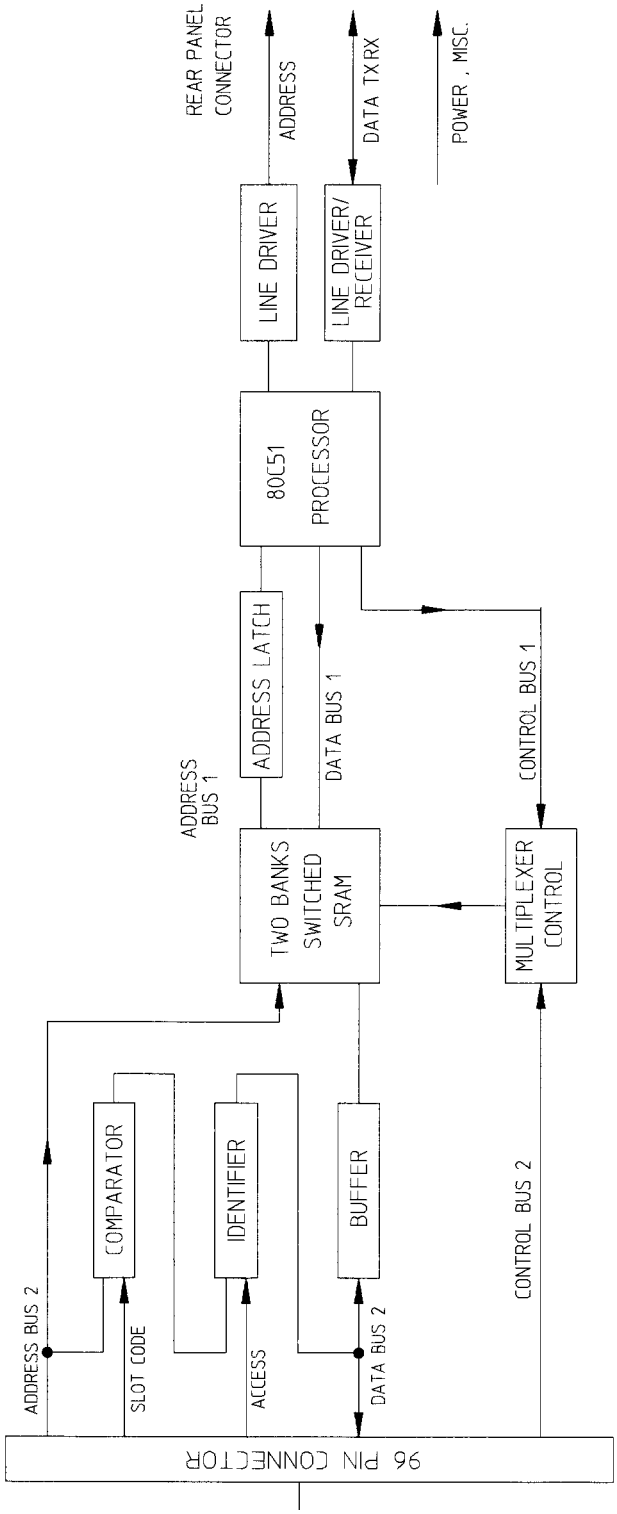


Figure 3-50 Rack Interface Card Block Diagram

Aux Connector Card

Introduction

The Aux Connector card provides access to the connector on the Rack Interface card behind the sheet metal cover of the M1046B Computer Module.

Connections

The Aux Connector card is placed in slot 24 of the M1046B Computer Module. The Aux Connector card has two circuit boards connected by a flex board. The larger board is placed in slot 24 of the M1046B Computer Module and the smaller board has a connector that plugs into the Rack Interface card in slot 18.

The larger of the two boards has two connectors, an ECG connector for defibrillator synchronization and an FE-Link connector to attach satellite module racks. The FE-Link connector has the cable to the satellite rack attached behind the Computer Module's plastic cover and the cable is routed under the Computer Module to the back. The ECG connector has an ECG adaptor so that it can be accessed through a hole in the plastic cover.

Remote Switch Card

Introduction

The Remote Switch card provides connection and the remote switching of the DC power to the computer module, the module racks and the flatscreen display.

Connections

The Remote Switch card is placed in slot 8 of the M1046B Computer Module. A cable from the M1046B Computer Module's integral power supply is connected to the Remote Switch card connector.

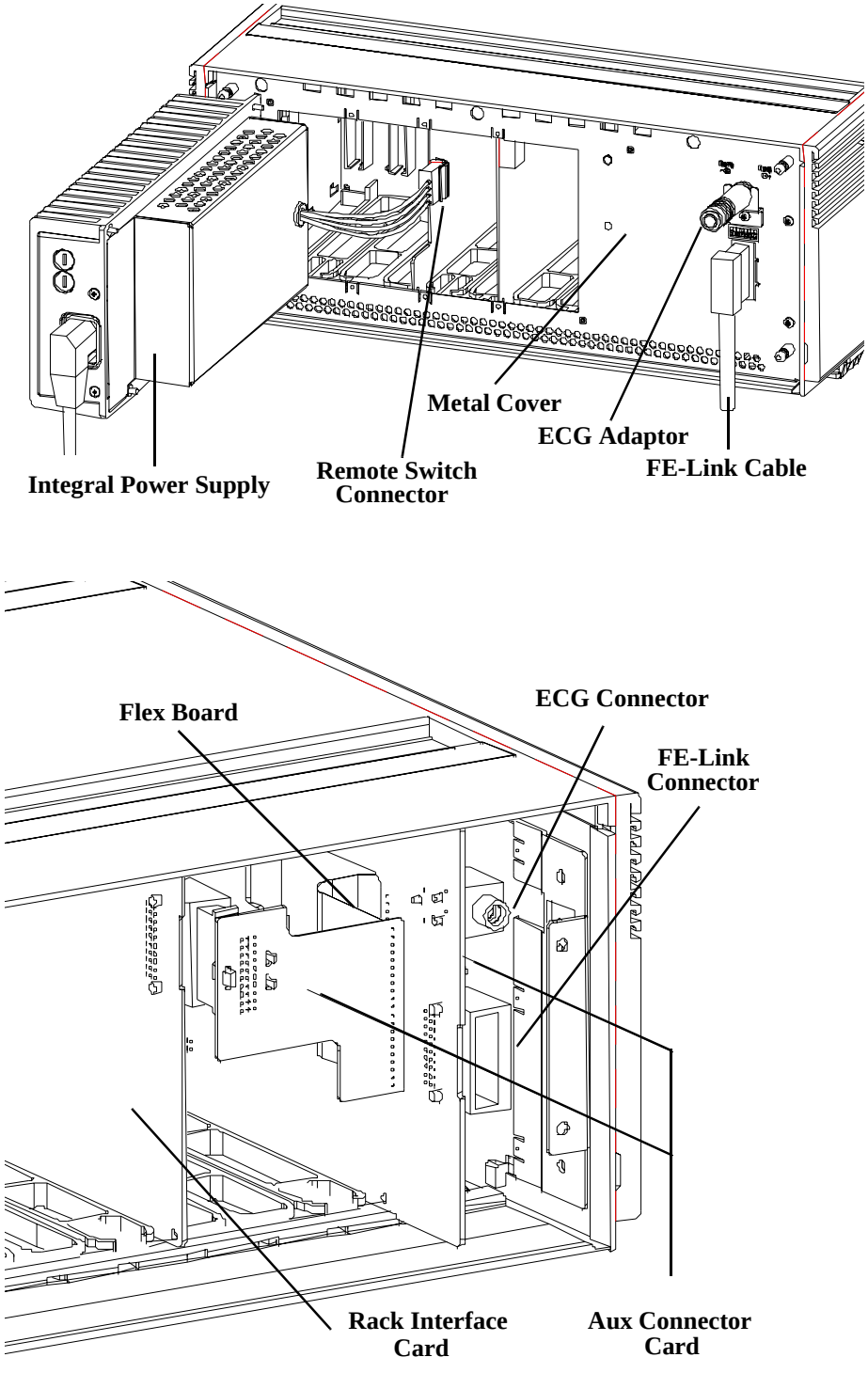


Figure 3-51 Remote Switch and Aux Connector Function Cards

Chapter 4 V24 and V26 Patient Monitors

Introduction

This chapter provides an overview on the operations, functions and components of the Philips M1205A V24 and V26 Patient Monitors (hereafter referred to as V24/V26 or the monitor).

Goals

After successfully completing this chapter, you should be able to:

- Describe the system's operations.
- Describe the system's functions.
- Identify the system's components.

Objectives

In order to meet the chapter's goals, you should be able to:

- Describe the purpose of the V24/V26 and the clinical settings in which it is typically used.
- Describe the major features and functions of the V24/V24C/V24CT.
- Describe the V24/V26' system processes and interfaces.
- Identify the standard and optional Plug-in modules used by V24/V26.
- Identify the user controls and connectors on the V24/V24C/V24CT.
- Identify the V24/V26' possible software configurations.
- Identify the V24/V26' major hardware configurations.

Topics

This chapter contains the following topics:

Chapter Topics

Topic	Page
V24 and V26 Patient Monitors Description and Features	3-3
V24 and V26 Patient Monitors Interfaces	3-11
V24 and V26 Patient Monitors User Controls and Connectors	3-14
V24 and V26 Patient Monitors Software Configurations	3-20
V24 and V26 Patient Monitors Theory of Operation	3-23

V24 and V26 Patient Monitors Description and Features

Introduction

The V24 and V26 are highly flexible patient monitoring systems, which are based on a variety of components that enable easy customization to a hospital's requirements. It utilizes a subset of the same parameter modules as the CMS, with similar operator controls and waveform display.

Objectives

After completing this section, you should be able to:

- Describe the purpose of the V24/V26
- Identify the clinical settings in which the V24/V26 is used.
- Identify the V24/V26' general features.

Concepts

The V24/V26 is a flexible, bedside monitor for critical and acute care units, and for patient transport between units (V24CT). It contains a user interface similar to the *Standard Control Panel* of CMS/ACMS, and supports a subset of the functionality of the CMS/ACMS.

Clinical Uses

The V24/V26 is designed to monitor patients in most critical and acute patient care areas of the hospital as well as in transport situations (V24CT). As a bedside monitor, the V24/V26 is most commonly seen mounted to a wall channel with a six- or eight-slot Plug-in Satellite Rack mounted below it. It can also be mounted on a table mount and a roll stand. As a transport monitor (V24CT) a six-slot rack can be docked directly to the mainframe. The V24/V26 supports a network connection to the Philips monitoring network (SDN). The V24, V24C, V26C's source of power is a local AC power connection. The V24CT is powered by either internal rechargeable batteries or from an AC power connection.

Product Releases

The V24/V26 is in its fifth release and currently supports a subset of the functionality of the CMS at C.0.

V24 and V26 Patient Monitors Standard Package

The V24/V26 bedside monitor standard package includes:

- Mainframe with 9.5" passive matrix monochrome flat panel display (V24); mainframe with 10.4" color flat panel display (V24C/V24CT) capable of displaying four, or in the case of the V26C/V26CT,six waveforms simultaneously.
- Eight-slot Plug-in Satellite Rack with front-end link cable
- Parameter Modules: predefined combinations of ECG/Resp, NBP, SPO_2, InvPRESS, CO_2, VueLink, and Recorder
- Patient Monitoring supplies

Features

The V24/V26 has the following general features:

- Mainframe with monochrome display (V24); mainframe with color display (V24C/V24CT and V26C/V26CT) for display of up to six waveforms.
- Eight-slot or optional six-slot Plug-in Satellite Rack to hold plug-in modules.

- Optional battery operation (V24CT/V26CT).
- All parameter modules supported by CMS except FiO_2, SvO_2 and EEG.
- Network Compatible through the Philips patient care system interface.
- Patient Data Management software which provides 24 hour storage of patient related parameter information.
- ST Segment analysis software.
- OxyCRG display software.
- Neonatal Event Review software
- Extended arrhythmia detection when networked to one of Philips' Arrhythmia Systems.
- Allows transfer of patient related settings and transfer of patient cables and lines without recabling or recalibration.

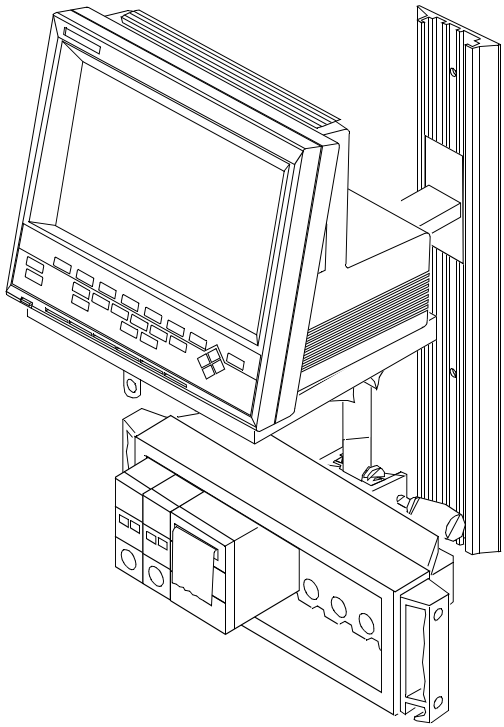


Figure 4-1 Philips V24 and V26 Patient Monitors Standard Package

Mainframe

The mainframe contains the display unit and the processing capabilities for the V24/V26. A computer subsystem is responsible for parameter processing, display control, and interfacing. The display section consists of a 9.5” (diagonally measured) monochrome display (V24); mainframe with 10.4” color display (V26C/V26CT and V24C/V24CT).

Rack Features

There are two rack options for the V24/V26; either the eight-slot or six-slot rack can be used. The standard eight-slot rack attaches to the monitor by a front end cable. It houses up to eight standard single-width CMS modules. The six-slot rack comes equipped with a standard front-end link connector for attachment to the V24/V26 or to other CMS models. The V24CT/V26CT supports docking the six-slot rack directly to the monitor mainframe.

Parameter Modules

The V24/V26 provides 6 or 8 slots to support the following parameter modules:

Table 4-1 Compatible Philips Plug-In Modules

Model Number	Parameter Module	Number Supported
M1001A/B	ECG	Maximum of one M1001A or M1002A per monitor.
M1002A/B	ECG/RESP	
M1006A/B	Pressure	Maximum of three per monitor (bundle specific)
M1006A/B Option #C01	Pressure Module with Analog Pressure Output	Maximum of one per monitor (total of two invasive pressure modules possible)
M1008A	NBP Adult	Maximum of one per monitor
M1008B	NBP Adult//Pediatric/Neonatal	
M1012A	Cardiac Output	Maximum of one per monitor (bundle specific)
M1015A	Side Stream CO_2	Maximum of one per monitor (bundle specific)
M1016A	CO_2	Maximum of one per monitor (bundle specific)
M1018A	tcpO2/tcpCO2	Maximum of one per monitor - only with Neonatal options
M1020A	SpO_2 /PLETH	Maximum of one per monitor
M1022A	Blood Analysis Module	Maximum of one per monitor (bundle specific)
M1029A	Temperature	Maximum of two per monitor (bundle specific)
M1032A	VueLink	Maximum of one VueLink A and VueLink B per monitor - except Anesthesia option H03 (VueLink B only)
M1116A or M1116B	Thermal Array Recorder	Maximum of one per monitor
M1026A	Anesthetic Gas Module	Maximum or one per monitor - only with Anesthesia options

Philips Patient Care System

A single upstream Philips monitoring network (SDN) connector allows connectivity to a Philips patient care system. This allows the V24/V26 to access waveforms, numbers, and alarms from other networked patient monitoring bedsides. It also allows connection to a Component Central Station, Philips Information Center, and extended Philips Arrhythmia Monitoring Systems. The V24/V26 supports the CMS Rev. E-Beta Inter-SDN Gateway functionality which includes:

- Overview
- VCP (Virtual Circuit Protocol)
- VTP (Virtual Terminal Protocol)
- DBQ (Database Query)
- Central recorder(s)
- Centralized arrhythmia
- Inter-SDN Gateway compatibility (>24 beds)

Data Management

The V24/V26 features Patient Data Management. This consists of continuous 24-hour storage of patient related parameter information. This allows you to:

- manage patient information
- view patient data in graphs or tables
- print patient information reports to a local printer or via a Philips central station.
- transfer data between V24/V26 and CMS monitors via the Data Transfer Module

Vital Signs Recording

This standard feature allows you to print out all active parameter labels, numerics, physiological and technical alarms on the M1116A/B Recorder Module. Vital signs are sequentially printed each time an NBP measurement has been taken, or automatically at user-defined time intervals.

Split Screen Capability

The Split Screen capability can display up to 30 minutes of trend data (1 minute resolution) next to configured waves on the display.

In addition, related alarm limits are shown graphically and numerically, providing an early indication of upcoming problems.

Clinical Calculation Set

Stored and manually entered data can be used to perform hemodynamic, ventilation, and oxygenation calculations. Calculated data is displayed in both indexed and non-indexed format.

Drug Calculator

The Drug Calculator allows you to calculate various drug infusion variables for a selected drug at the bedside. The Drug Calculator contains 16 pre-configured drugs and 8 “any dose” formats

A titration table can be displayed and printed.

Arrhythmia Detection

The V24/V26 will present all arrhythmia status messages, delayed annotated waveforms and all arrhythmia data management functions when networked to a Philips arrhythmia monitoring system listed below:

- Philips 78504/508 with Philips 78720
- Philips 78560A with arrhythmia option
- Philips M2340A
- Philips M2350A
- Philips M2360A
- Philips M3150A/M3153A

Anesthetic Gas Monitoring

The (optional) M1026A Anesthetic Gas Module (AGM) provides a non-dispersive infrared measurement of respiratory and anesthesia gases. It is intended for measurement of airway gases of ventilated patients within the anesthesia workplace during induction, maintenance of, and emergence from anesthesia.

Alarms

When an alarm limit is exceeded it is presented in 3 ways:

- Alarm tone (graded according to severity)
- Alarm Message (color coded according to severity)
- Alarming parameter value flashes.

All alarms are transmitted on the Philips patient care system

Graded Alarms Alarms are graded and prioritized according to severity.

Red Alarms Identifies asystole, ventricular fibrillation, apnea, bradycardia (in neonates and pediatrics), and pressure disconnect conditions.

Yellow alarms Alert clinicians when alarm limits are exceeded.

Technical Alarms (INOPS) Are triggered by signal quality problems, equipment malfunction, a measurement that is not set up, or an ongoing calibration.

Resetting and Suspending Alarms The Silence/Reset key on the display control panel allows you to silence alarm tones, while retaining visual alarm messages (depending on the monitor's configuration).

Alarms can be indefinitely suspended or suspended for 1, 2, or 3 minutes, after which alarms will automatically reactivate.

Alarm Recording To prevent unwanted alarm strip recordings, it is possible to configure which parameters will trigger an alarm strip.

ST Segment Analysis

ST Segment Analysis software allows you to measure the elevation or depression of the ST Segment on up to three leads of a patient's ECG. The ST measurements are shown as numerics on the flat panel and are available in table and graphic trend displays in Patient Data Management. The V24/V26 uses the CMS Rev. E-Beta version of the ST application.

oxyCRG

The Oxygen CardioRespiroGram (oxyCRG) display provides a simultaneous presentation of 3 waves:

- beat to beat heart rate (btbHR)
- compressed respiration rate
- an oxygenation parameter trend (SpO_2 or $tcpO_2$)

Each waveform shows a 6 minute interval, allowing you to compare patterns related to physiological or pathophysiological processes and detect respiratory conditions typical of neonates.

Neonatal Event Review

Neonatal Event Review provides automatic documentation and review of up to 24 events from the last 24 hours. At one glance you can see and review the number of events and categories, such as bradycardia, apnea with associated bradycardia or isolated desaturation event.

Settings Transfer

Plug-in modules which are labeled on the front with a "T" can be transported from one rack to another (or from one Philips system to another) and still keep their parameter settings. The settings (such as alarm limits) are stored inside the module. You could even unplug a satellite rack full of these modules from one monitor, and plug it into another monitor without losing the parameter settings. This behavior permits fast and easy transport, and is called "Parameter Settings Transfer". For Parameter Settings Transfer to work on your monitor, it must be set ON in a special Service Mode, either by the biomedical engineering department or the Philips service engineer.

V24 and V26 Patient Monitors Features Exercises

1. What is the V24/V26?

   a. an eight-channel color monitoring system with the capability of processing up to eight single-width parameter modules.

   b. a four-channel monochrome or a six- or four-channel color monitoring system with the capability of processing up to eight single-width parameter modules.

   c. a six-channel monochrome monitoring system with the capability of processing up to six double-width parameter modules.

2. The V24/V26 has the following general features:

   a. Allows transfer of patient related settings
   b. Philips monitoring network (SDN) compatible
   c. both a and b

3. The rack options for the V24/V26 are:

   a. six- or eight-slot
   b. two- or four-slot
   c. four- or six-slot

4. Patient Data Management is the:

   a. 18 hour tracking of patient information
   b. 12 hour tracking of patient information
   c. 24 hour tracking of patient information

5. What rack is standard with the V24/V26?

   a. four-slot rack
   b. six-slot rack
   c. eight-slot rack

6. The current release of V24/V26 supports a subset of the functionality of which monitor?

   a. CMS Release C.0
   b. CMS Rev C+

Answers
1. b
2. c
3. a
4. c
5. c
6. a

V24 and V26 Patient Monitors Interfaces

Introduction

The following section describes the V24/V26 and the interfaces it uses.

Objectives

After completing this section, you should be able to describe the interfaces used with the V24/V26.

Concepts

Concepts important to the V24/V26 interfaces:

- **Alert information**- Information that signals an alarm.
- **Parametric information** - Information that is presented as numerics.
- **Philips monitoring network (SDN) -** Serial Distribution Network
- **Upstream** - Accepts information from another source.
- **Waveform** - Information that is presented as waves.

Overview

Connectors are provided for various functionality. These functions are further explained below:

- Philips monitoring network (SDN) interface
- RS232 Interface
- Front-End Link Protocol for Racks (FELP)
- Service Ports
- AC Power Connector
- Defib Sync/ECG Output Connector

Philips Monitoring Network (SDN) Interface

A single Philips monitoring network (SDN) connector (upstream only, no downstream connector) is available to allow connection to a Philips monitoring network (SDN). This allows the V24/V26 to show waveforms and alarms of interest from other networked bedsides. It also allows connection to a Central Station as well as centralized arrhythmia systems. V24/V26's single Philips monitoring network (SDN) connector means it must be the last instrument on a Philips monitoring network (SDN) branch.

The Philips monitoring network (SDN) interface subsystem consists of the physical interface to the Philips monitoring network (SDN) and controlling firmware. The interface communicates with the Philips monitoring network (SDN) interface module and physical network.

Digitized patient information displayed over the Philips monitoring network (SDN) may be either waveforms (for ECG, pressure, respiration), parametric information (for

heart rate/pulse, pressure values, and respiration rate) or alert information (for alarms and assorted status information). The Philips monitoring network (SDN) data transmission rate of 3.6 Mbits/sec can provide 7700 usable 12-bit data words per 32 millisecond poll cycle. The Philips monitoring network (SDN) is a half-duplex network using shielded twisted pair cables. All data is transmitted differentially and serially using block code modulation.

Within the connected instruments, the Philips monitoring network (SDN) interface circuitry provides the link between the serial digital network and the rest of the instrument. Each instrument connected to the Philips monitoring network (SDN), except Philips care hub (SCC), has basically the same interface circuitry, most of which is contained on a custom integrated circuit called the SDN Interface Circuit Chip (SIC Chip). This chip has been redesigned for the V24/V26, for more integration of circuitry within the SIC chip.

RS232 Interface

The (optional) RS232 interface has 1 port that permits connection to the M1026A AGM, connection to a personal computer via MECIF (MEdical Computer InterFace), or local printing capability.

The RS232 interface subsystem consists of the physical interface to the RS232 network and controlling firmware. The connector type used is a 9 pin D-sub female and is located at the rear of the V24/V26 mainframe.

Front-End Link

The parameter rack, generally located near the patient, is connected to the mainframe by a serial front-end link. a Philips proprietary front-end link connector is on the left side of the V24/V26 for attachment to a rack by a cable. This front-end link operates identically to the front-end link used in the CMS. There is a four meter maximum length for the cable length (rack to mainframe).

Service Port

Both the application and utility processors have dedicated service ports. Both are upgradeable by the CPC service tool. (The front end rack software is not externally upgradeable.)

AC Power Connector

A standard CEE connector (IED Type 320) is located at the rear of the V24/V26 Mainframe. A detachable country-specific line cord is supplied.

Defib Sync/ECG Output Connector

The connector has the same form, fit, and functionality as in CMS. This three circuit phono jack connector is located on the upper left side of the V24/V26 Mainframe.

V24 and V26 Patient Monitors Interfaces Exercises

1. The Philips monitoring network (SDN) connector used with the V24/V26 is:

   a. both an upstream and downstream connector
   b. a downstream connector
   c. an upstream connector only

2. Digitized patient information transmitted over the Philips monitoring network (SDN) may be either:

   a. waveforms
   b. parametric information
   c. both a and b

3. The standard CEE connector is located at:

   a. the front of the V24/V26 mainframe
   b. the rear of the V24/V26 mainframe
   c. on the left side of the V24/V26 mainframe

Answers
1. c
2. c
3. b

V24 and V26 Patient Monitors User Controls and Connectors

Introduction

The following section describes the V24/V26 and its User Controls and Connectors.

Objectives

After completing this section, you should be able to:

- Identify the User Controls on the V24/V26.
- Identify the Connectors used with the V24/V26.

Concepts

Concepts important to the V24/V26 user controls and connectors:

- **Front Panel -** The panel where the User Controls are located.
- **Hardkey -** A key on the front panel which has a permanent function and label.
- **Softkey -** A key on the front panel that has a dynamically changing function and label, which corresponds to a label displayed on the screen.

User Controls

Overview

The V24/V26 display and control structure looks very similar to the CMS. The main functional distinctions from CMS are the number of waveforms (4 versus 4/6/8) and the size of the display and keys.

Display

In addition to the obvious dimensional differences between the CMS and V24/V26 displays, the number of pixels in both the horizontal and vertical axis differ as well.

The attributes in CMS cover a 4x2 pixel area. The blinking rate may appear to differ between CMS and the V24/V26 due to the slower response times of the flat panel displays.

Front Panel Controls

The V24/V26 front panel is a scaled-down version of CMS' Revision E front panel with a similar key layout. The V24/V26 key layout maintains consistency, for the most part, with the CMS user interface.

Shown below is the front bezel keypad for the V24 and V24C.

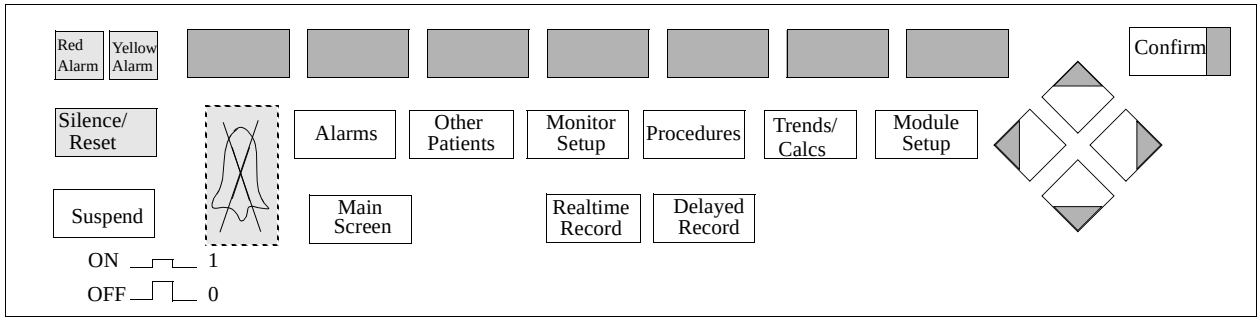


Figure 4-2 Philips V24 and V24C POC Front Keypanel Layout

Shown below is the front bezel keypad for the V24CT. The V24CT front panel contains additional battery and power indicators.

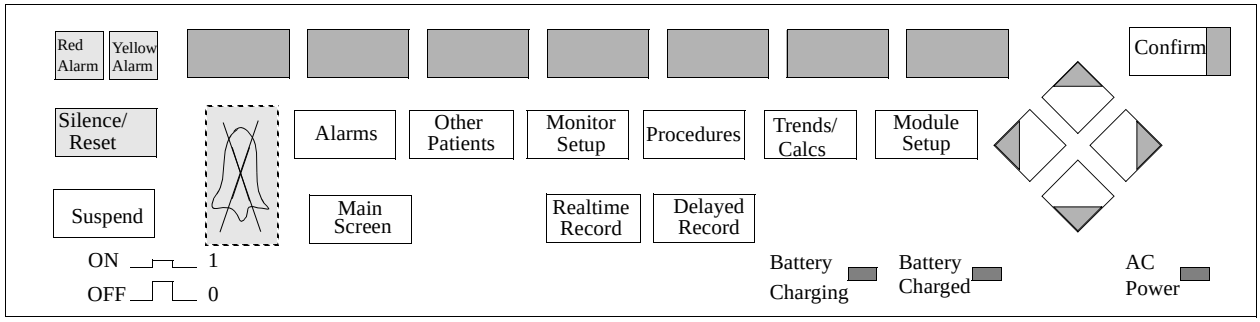


Figure 4-3 Philips V24CT POC Front Keypanel Layout

The V24/V26 Front Panel Keys

The function of front panel hardkeys and softkeys, as they pertain to V24/V26, are presented here. Differences between these keys as they operate within V24/V26 compared with CMS are discussed where appropriate.

Suspend Key

Pressing this key reverses the Alarms Suspend state. This key is functionally identical to CMS'.

Silence/Reset Key

Pressing this key silences an alarm. If the cause of the alarm has been eliminated, pressing this key resets the alarm. This key is functionally identical to CMS'.

Alarm Key

The <Volume Control> softkey has been eliminated from V24/V26's Alarm Array of Choices due to the availability of standard display volume controls. All other Alarm Control options are unchanged.

Other Patients Key This key (formerly called Overview in CMS) is functionally identical to CMS'.

Monitor Setup Key This key, (formerly Instrument Config in CMS) is functionally similar to CMS' with the following differences:

- There are three display modes for the V24/V26 display and up to six waves (non-overlapped and overlapped).

There is a background selection for the monochrome LCD: black text on a white background (for older versions), or white text on a black background. Background is not selectable on the color flat panel display.

Procedures Key This key (formerly Monitoring Procedures in CMS) is functionally identical to CMS'. A softkey for the Ht/Wt entry for Cardiac index calculation is in the Array of Choices for this key.

Trends/ Calcs This key (formerly Patient Data in CMS and Trends in V24) provides access to the Data Management functionality. The title on the Array of Choices is changed to Trend/Calcs to reflect the new key label.

Module Setup Key This key (formerly Parameters in CMS) is functionally identical to CMS'. It enables you to change or adjust parameter settings, switch parameters on or off, or set up parameters.

Main Screen Key This key (formerly Standard Display in CMS) is functionally identical to CMS'.

Realtime Record Key Pressing this key displays a Selection Window that gives choices for real time recording, which is a recording of the waveforms from the time of the request.

Delayed Record Key Pressing this key generates a delayed recording, which is a recording of waveforms that are no longer on the monitor screen.

Blank or Minus Key The function of these programmable softkeys varies with the application currently being used by the user.

Confirm Key This key is functionally identical to CMS'. It only functions when it is illuminated. A prompt message "...press CONFIRM.." appears on the screen when you need to use it.

V24/V26 User Controls Exercises

1. The main distinctions of the V24/V26 from CMS are:

   a. number of waveforms and the size of the display and keys
   b. the size of the monitor
   c. the number of user keys on the front panel

2. The V24/V26 front panel is a scaled down version of

   a. CMS' Rev E front panel
   b. CMS' Rev C+ front panel

3. Which key provides access to the Data Management functionality?

   a. Procedures key
   b. Module Setup key
   c. Trends/Calcs key

Answers
1. a
2. a
3. c

Connectors

Overview

The V24/V26 supports either a six-slot or eight-slot parameter rack.

Eight-slot Rack

The eight-slot rack is shipped with each standard V24/V26. This rack is the same M1041A Satellite rack used with the CMS. It accommodates up to 8 single width modules and is attached to the mainframe by a standard Front End Link cable to the V24/V26 Mainframe.

The V24/V26 does not support the connection of more than one rack and displays an error prompt if another rack (with a parameter module inserted) is attached.

Six-slot Rack

This rack accommodates up to six single width modules and is attached to the mainframe by a standard front end cable. The six-slot rack is dockable to the V24CT Mainframe.

The six module rack provides an optimized rack solution for monitoring. This rack matches the user's need for up to six single width CMS compatible modules.

Connectors Exercises

1. Which rack is shipped with the V24/V26?

   a. eight-slot rack
   b. six-slot rack
   c. four-slot rack

2. The 6 module rack matches the user's need for:

   a. a smaller piece of hardware
   b. up to 6 CMS compatible modules
   c. 8 CMS compatible modules

Answers
1. a
2. b

V24 and V26 Patient Monitors Software Configurations

Introduction

The following section describes the V24/V26 software and hardware configurations.

Objectives

After completing this section, you should be able to:

- Identify the V24/V26's software configurations.
- Identify the V24/V26's hardware configurations.
- Describe the major components of the Theory of Operation.

Concepts

Concepts important to the V24/V26 description:

- **ASW** - Application SoftWare modules
- **Operating System** - The software that performs data management and communications functions.

Overview

The software is divided into 4 major conceptual layers:

4. The first layer consists of the operating system that performs management functions and accomplishes intermodule communications. The operating system passes messages between the various manager modules. The operating system also performs system initialization, background error checking, and run-time checking.

5. The second layer consists of the monitoring manager modules. This layer includes the alarm, record, trend database, and heart rate selector.

6. The third layer consists of the interface manager modules and interface controllers. This layer consists of the display/operator, date/time, recorder and Philips monitoring network (SDN) managers.

7. The last layer consists of the monitoring algorithms and related CMS plug-in modules acquiring the physiological signals. This layer includes the standard CMS plug-in modules and monitoring algorithms.

Modules Partitioning

The V24/V26 software is modular and divided among 3 CPUs: Application CPU, Utility CPU, and the Front End microcontroller. The Application CPU contains the interface managers, monitoring managers and monitoring algorithms. The Utility CPU contains the low level interface controllers. The Front End microcontroller serves as a high-speed intelligent UART to the CMS front end modules.

Application CPU Architecture

The software architecture of the V24/V26 application CPU is the same as in the application CPUs in the other monitors. The software consists of the application software and the Operating System. The application software consists of Application SoftWare modules (ASWs). Each module implements a certain function, i.e., the pressure ASW implements the pressure function and the alarm handler ASW implements the alarm functions. The modules communicate over the message passing bus (MPB). The Operating System manages the hardware resources and schedules the routines of the application modules based on times routines and on MPB messages received.

Utility CPU Architecture

The Utility CPU functions as the display controller, FE interface controller, Philips monitoring network (SDN) controller, human interface controller, real time clock controller, and EEPROM controller. All of the software runs under the control of OS/i operating system. Communication with the Application processor is through the MPB (Message Passing Bus). Communication with the Front End CPU is through a shared memory buffer.

Front End Microcontroller Architecture

The FE microcontroller is a CMOS 87C51 and is primarily responsible for communication with the Front End Rack. The FE microcontroller communicates with the Utility CPU through shared RAM. In addition to Front End Link communication, the FE microcontroller is responsible for generating analog ECG output by an 8 bit D/A converter. Analog ECG output is accessed through a phono jack on the V24/V26.

V24/V26 Software Configurations Exercises

1. The monitoring manager modules include:
   a. alarm
   b. trend database
   c. both a and b

2. The FE microcontroller is primarily responsible for:

   a. data management
   b. communication with the Front End rack
   c. trend setting

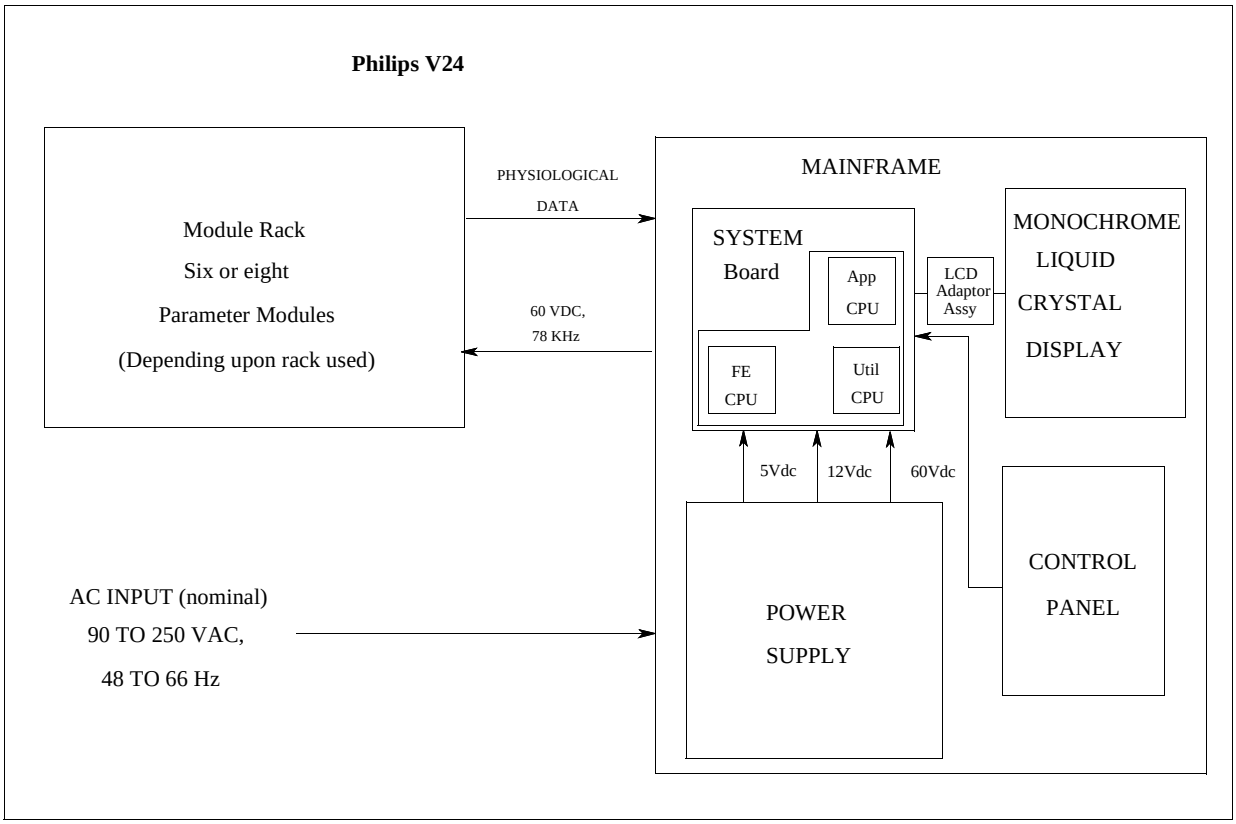
Answers
1. c
2. b

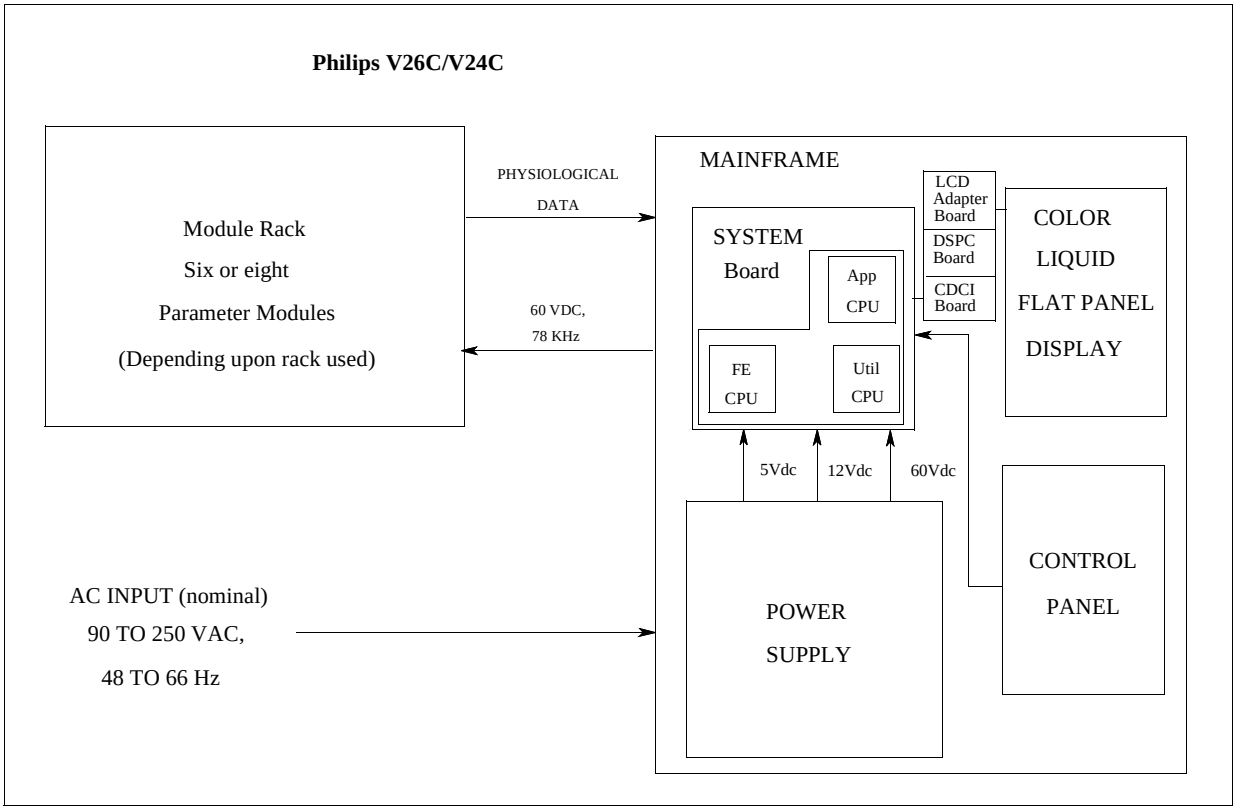
V24 and V26 Patient Monitors Theory of Operation

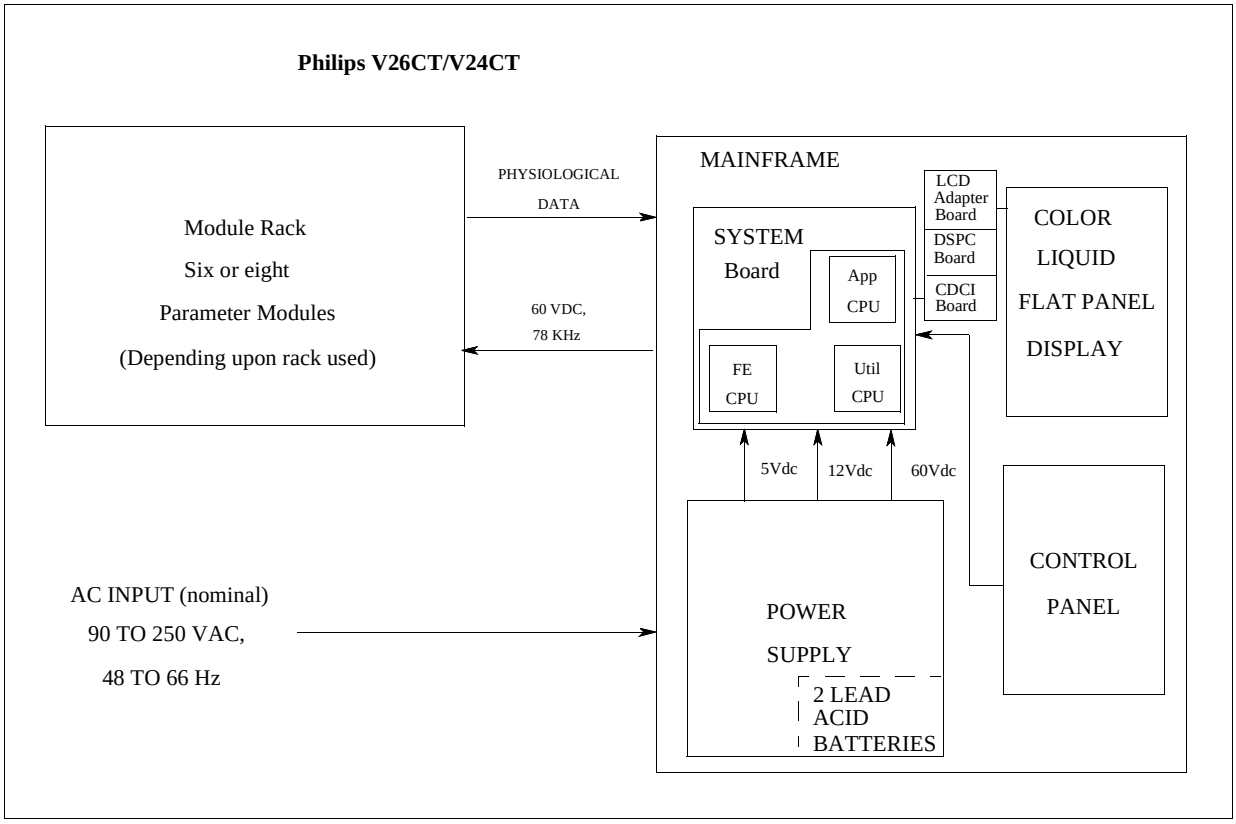
Overview

The V24/V26 consists of the following:

- an internal power supply which supplies all of the voltages required for V24/V26 operation
- a System Board which performs all of the processing functions
- a LCD Adaptor Board (V24)
- a 3 board assembly, consisting of LCD Adapter Board, DSPC Board, and CDCI Board (V24C/V24CT and V26C/V26CT only)
- a front panel keypad
- a flat panel display
- Service Port Connector
- six-slot or eight-slot racks




Philips V26C/V24C
Module Rack
Six or eight
Parameter Modules
(Depending upon rack used)
PHYSIOLOGICAL
DATA
60 VDC,
78 KHz
MAINFRAME
SYSTEM
Board
App
CPU
FE
CPU
Util
CPU
LCD
Adapter
Board
DSPC
Board
CDCI
Board
COLOR
LIQUID
FLAT PANEL
DISPLAY
5Vdc
12Vdc
60Vdc
CONTROL
PANEL
POWER
SUPPLY
AC INPUT (nominal)
90 TO 250 VAC,
48 TO 66 Hz



V24, V24C, V26C Power Supply

The V24, V24C, V26C power supply provides the following power outputs:

V24	V24C/V26C
+5 Volts @ 2.0 Amps, max	+5 Volts @ 2.5 Amps, max
+12 Volts @ 2.0 Amps, max	+12 Volts @ 0.75 Amps, max
+60 Volts @ 0.35 Amps, max	+60 Volts @ 0.35 Amps, max

V24CT/V26CT Power Supply

The V24CT operates from an internal battery power supply, or from an external AC source. The internal power is provided by one or two lead-acid batteries. The V24CT can operate on 90 to 250 VAC, 48 to 66 Hz, depending on local power sources. The Power Supply converts input power into three DC voltages for use in the transport mainframe, and for the plug-in modules in the transport rack. The power board communicates its status and the status of the internal batteries to the processors on the System Board.The V24CT power supply provides the following power outputs:

V24CT/V26CT Power Outputs
+5 Volts @ 2.8 Amps, max
+12 Volts @ 0.65 Amps, max
+60 Volts @ 0.3 Amps, max

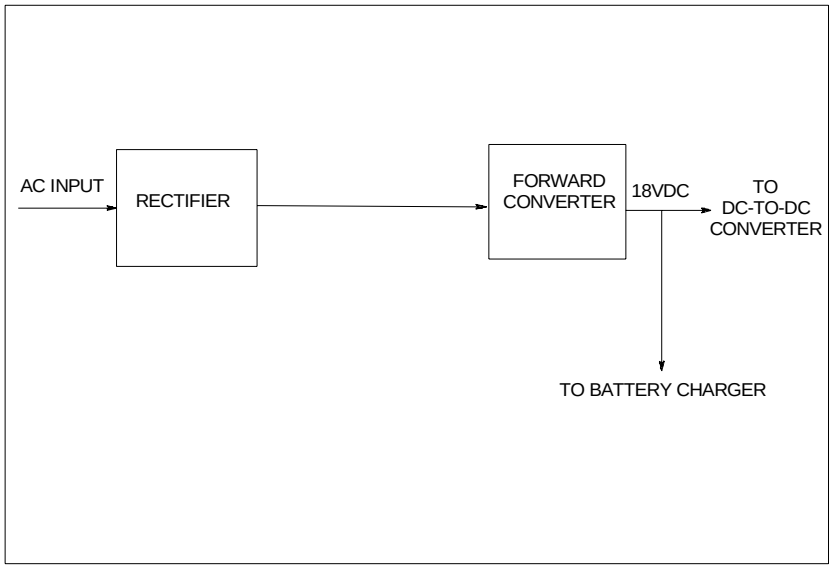
Subcircuits The Power Supply consists of four subcircuits:

- AC to DC converter
- Battery charger
- DC to DC converter
- Power Logic/CPU Interface

AC to DC Converter

The AC to DC converter subcircuit converts the AC line (90 to 250 VAC, 47 to 66 HZ) into a safety isolated DC output.

The input AC voltage is directly rectified to create a high voltage DC rail (100 to 350 VDC). The voltage rail feeds a high frequency (100 khg) switching connector. This generates a safety isolated 18 VDC (Vch at pin 30 of connector J3B) used to power the battery charger and DC to DC converter.



Battery Charging Circuit

The battery charging circuit contains two identical battery charger circuits which control the charge of the two sealed lead-acid batteries through four distinct states. These states are:

State	Description
1	On power-on reset or if the battery voltage is less than 12.33 V at 25ºC, a constant current is sourced to the battery. The current has a value of 0.83 amps if the monitor is switched off or 0.19 amps if the power switch is on.
2	When the battery voltage reaches 14.7V at 25ºC, the voltage is regulated to this value and charge current tapers off. When charge current tapers off to 42mA, the charging circuit switches to the next state.
3	A four to five hour time is started and battery voltage is regulated to 13.7V at 25ºC. A signal indicating the battery is more than 90% charged is given.
4	After a time-out, the charger is disabled. The charger is re-enabled into state 1 if the battery voltage drops below 12.33V at 25ºC or if power is cycled.

The following figure shows a graphical representation of the battery charging circuit states.

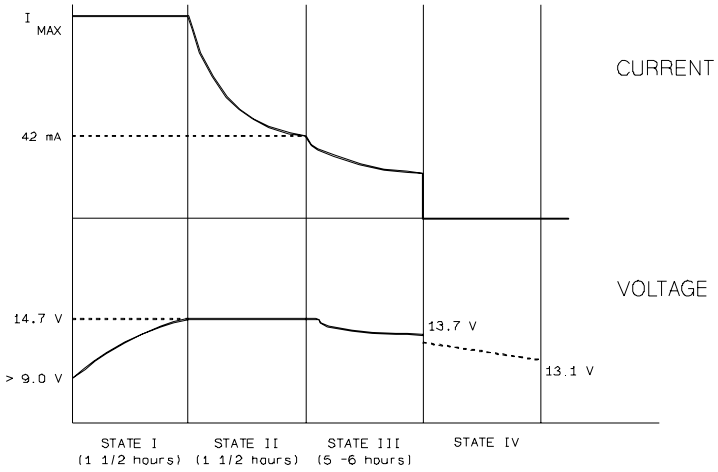


Figure 4-4 Battery Charging States

Charger Operation - State 1

The charger circuit receives input from the non-switchable 18 Vdc output of the AC/DC power supply. The charging circuit contains two identical battery charger circuits. The following description applies to either battery charger circuit.

The Sealed lead-acid battery charging circuit regulates the charge to the battery. The circuit contains a temperature sensitive voltage reference tuned for optimum regulation of charge voltage to lead-acid batteries.

When the battery is inserted, a mechanical sense contact pulls the input to a debounce circuit low. This allows the charger circuit to proceed with the first state.

Charger Operation - State 2

The charging circuit enters the second state when the battery voltage reaches 14.7V. At this point, a voltage amplifier regulates the battery at that value. The battery voltage is sensed and divided and applied to a current sense comparator which senses when the voltage reaches 25 mV and trips internal state latches to state three. The battery charge current falling to 42mA marks the end of state 2.

Charger Operation States 3 and 4

In the third state, the battery voltage is regulated to 13.7V for 4 to 5 hours. Also, in the third state, a state level control line is pulled high. This lowers the voltage regulation point. It also causes the FLT1 (FLT2) signal to go low. When both FLT1 and FLT2 are low, the LEDCRGD line is pulled low turning on the front panel BATTERY CHARGED LED. The low state of FLT1 (FLT2) also enables the timer for the third state. The timer circuit disables the third state after approximately 5 hours.

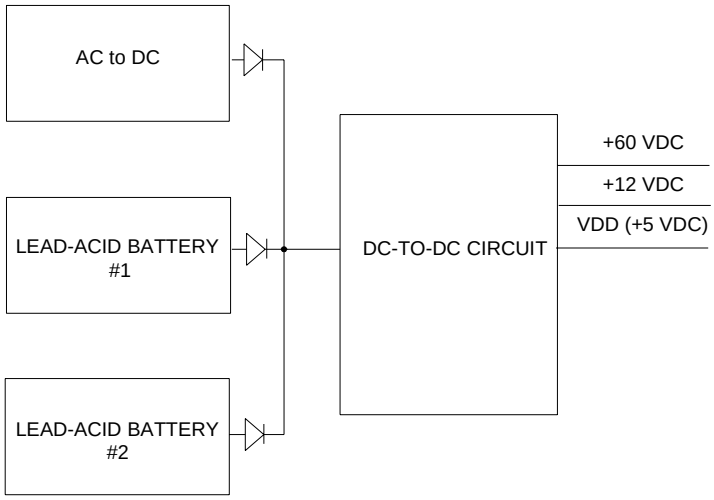
The fourth state is entered when the third state is disabled. The charger would be re-enabled into the first state if the battery voltage drops below 12.33V at 25ºC, or if the AC line cord is disconnected then reconnected.

During the charging cycle, the Battery Charging and Battery Charged LEDs are controlled by a PAL in the charging circuit. When at least one battery is present and greater than 9.0 Vdc (open circuit), the Battery Charging LED flashes at a slow rate and the Battery Charged LED is off. If two batteries are present and the both chargers enter state 2, the Battery Charging LED remains illuminated. It is important to note that if only one battery is present, the Battery Charging LED continues to flash when the charger for that battery enters state 2; the Battery Charging LED can only be illuminated constantly when two batteries are present and both have entered state 2. When both batteries are present and both chargers enter state 3, both the Battery Charging and Battery Charged LEDs remain illuminated. When the chargers enter state 4, the Battery Charging LED extinguishes, and the Battery Charged LED remains illuminated. The Battery Charged LED remains illuminated until the AC power cord is disconnected.

DC to DC Circuit

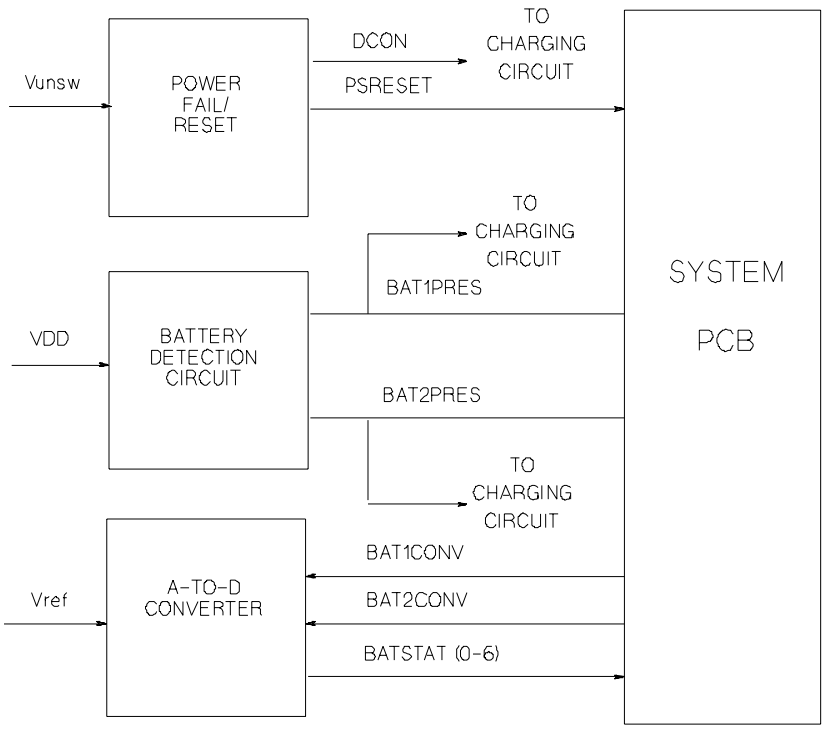
The DC to DC converter receives input from the lead-acid batteries, or from the output of the AC to DC power supply, depending on the operating mode. The converter provides three DC outputs:

- +60 VDC, power supply connection to front-end rack and parameter modules
- +12 VDC, the general purpose analog supply
- VDD, the general logic supply, +5V nominal



Power Logic/CPU Interface

The power logic/CPU interface circuit consists of three circuits which communicate the state of the DC-to-DC converter and the batteries to the System PCB. The three circuits are: power-fail/reset, battery detection, and battery voltage analog-to-digital converter.



The power fail/reset circuit alerts the System PCB that DC-to-DC conversion will halt in 2ms during power down via the PSRESET signal.

The battery detection circuit determines whether either battery is inserted. If a battery is present, the circuit routes a low BAT1PRES or BAT2PRES2 signal to the System PCB. If a battery is not present, BAT1PRES or BAT2PRES is set high. A logic high on either of these lines also goes to the battery charger to disable the charger for the appropriate battery.

The battery voltage analog-to-digital converter converts each battery voltage sequentially into a seven-bit word. The System PCB selects which battery to sample using the BAT1CONV and BAT2CONV lines. The seven-bit words, BATSTAT (0-6) go to the System PCB for state-of-charge determination and low battery detection.

System Board

The System Board contains the microprocessors and circuitry to acquire and process physiological data from the plug-in modules. It consists of four subsystems:

- Application subsystem
- Utility subsystem
- Front End Interface subsystem
- Common subsystem

Application Subsystem

The Application subsystem uses the Application CPU to work with parameter modules to process the physiological signals. It also processes the system core applications. The Application subsystem has its own dedicated memory and an MPB interface chip.

Utility Subsystem

The Utility subsystem uses the Utility CPU to perform all non-application-based tasks such as display communication, interface to the parameter modules and front panel, control of the EEPROM, and reading and writing to real-time clock. The EEPROM is used for system configuration storage.

Front End Interface Subsystem

The Front End Interface subsystem contains a front end interface CPU which allows the Utility subsystem to communicate to the front end rack-mounted parameter modules. The Utility subsystem accomplishes this by sharing RAM space between the Application CPU and the Front End Interface CPU. Two physical RAMs are multiplexed between the two CPUs. The Front End CPU communicates over a serial link to a selected module using a polling scheme. The Front End CPU then places the appropriately formatted data in the shared RAM so it can be accessed by the Utility CPU.

RAM selection can be generated by either the Utility CPU or the Front End CPU.

The parameter module interface subcircuit also has an analog section that allows an external defibrillator to be synchronized to an ECG signal. The ECG signal goes from the Front End CPU to a digital-to-analog converter and its filtering circuitry. The conditioned ECG signal goes to the defibrillator which responds by sending a marker pulse to the Front End CPU, which processes it along with the ECG signal.

Common Subsystem

This subsystem provides both the application and utility subsystem with reset signals, power fail interrupts, master clock, and other miscellaneous clocks.

Front Panel Keyboard

The V24/V26 keypad provides the operational interface. The front panel interface circuit on the System Board scans the front panel keypad, controls the LEDs, and produces the analog waveforms to drive the speaker. The Front Panel CPU performs the processing for the circuit.

Flat Panel Display

V24
The V24 liquid crystal display (LCD) subassembly is a 640 pixel x 480 pixel full dot monochrome graphic display unit consisting of the LCD panel, a fluorescent tube for backlighting, and LCD driver row and column circuits.

V24C/V24CT and V26C/V26CT
The V24C/V24CT and V26C/V26CT flat panel display subassembly is a 640 pixel x 480 pixel color graphic display unit consisting of the flat panel display, a fluorescent tube for backlighting, and driver row and column circuits.

Display Adapter Board

The V24 LCD Adapter Board provides

- a location for the backlight inverter assembly.
- an interface to the LCD.
- a location for LCD bias and contrast/brightness circuitry.
- encoded data about panel type and dot pitch.

3 Board Assembly

The V24C/V24CT and V26C/V26CT 3-board assembly provides

- an LCD Adapter Board for interfacing to the flat panel display.
- a DSPC board for display control.
- a CDCI board for interfacing to the System Board.

NOTE

The backlight inverter circuitry for the V24C/V24CT and V26C/V26CT is integral to the flat panel. This note does not apply to the new flat panel assembly, which was introduced with Rel. A.0. Here, the inverter is a separate assembly. **The latest hardware provides only one driver board instead of a 3 board assembly.**

Service Port Connectors

The Service Port Connectors on the System Board align with the cover on the right side of the mainframe to provide access for programming the Utility and Application software.

Six-slot Rack Eight-slot Rack

The six-slot rack holds up to six single width parameter modules. The eight-slot rack holds up to eight single-width parameter modules. Parameter modules can be either single-width or double-width. There are two connectors for external connections: a downstream connection for multiple rack configurations, and an upstream connector. The V24/V26 does not support the connection of more than one rack.

V24/V26 Theory of Operation Exercises

1. What is the purpose of the LCD Adapter Board?

a. provides an interface to the LCD
b. eliminates the shock mounting feature

Answers
1. a

Chapter 5 Philips Monitoring Network (SDN)

Introduction

This chapter describes the Philips monitoring network (SDN) and the Inter-SDN Gateway. Philips monitoring network (SDN) provides network connectivity for the Philips patient monitoring system. The Inter-SDN Gateway expands the number of bedside monitors that can be accessed by connecting SDNs together.

This chapter assumes that you have completed the first four chapters of this manual and that you are familiar with the concepts and workings of the CMS and V24/V26 bedside monitors.

Goals

After successfully completing this chapter, you should be able to:

- Describe the Philips monitoring network (SDN) system's features.
- Describe the Philips monitoring network (SDN) system's functions.
- Describe the Philips monitoring network (SDN) system's components.

Objectives

In order to meet the chapter's goals, you should be able to:

- Describe the Philips monitoring network (SDN).
- Identify the Philips monitoring network (SDN) components.
- Describe how the Philips monitoring network (SDN) works.
- Describe the Inter-SDN Gateway.

Topics

This chapter contains the following topics:

Chapter Topics

Topic	Page
Defining the Philips Monitoring Network (SDN)	5-2
Philips Monitoring Network (SDN) Components	5-3
How the Philips Monitoring Network (SDN) Works	5-4
Defining the Inter-SDN Gateway	5-8

Defining the Philips Monitoring Network (SDN)

The Philips monitoring network (SDN) is a local area communications network for sharing patient physiological parameters and other data between CMS and V24/V26 bedside monitors, central stations, recorders, and computer systems. The Philips monitoring network (SDN) is a digital communications network that transfers patient data between connected instruments and systems.

The Philips monitoring network (SDN) uses a proprietary network protocol that digitizes patient information collected at each monitor. The Philips monitoring network (SDN) collects patient information from each individual monitor and rebroadcasts that information out to the other monitors and systems connected to the Philips monitoring network (SDN).

The Philips monitoring network (SDN) performs the collection and rebroadcast of patient information without any user intervention. From the rebroadcast patient information, nursing staff can display information or receive automatic alarms for any patient being monitored by a CMS or a V24/V26 connected to the Philips monitoring network (SDN).

Any type of patient information can be transmitted, including waveforms, such as ECG, pressure, and respiration, and parametric information, such as heart rate/pulse, pressure values, and respiration rate. The Philips monitoring network (SDN) transmits this information at a rate of 3.6 Mbits.

Philips Monitoring Network (SDN) Components

The Philips monitoring network (SDN) components include:

- Philips care hub (SCC)
- Philips monitoring network (SDN) interface circuitry
- branch cables
- local distribution cables (LDC)
- wall boxes and face plates

Figure 5-1 illustrates some of the Philips monitoring network (SDN) components.

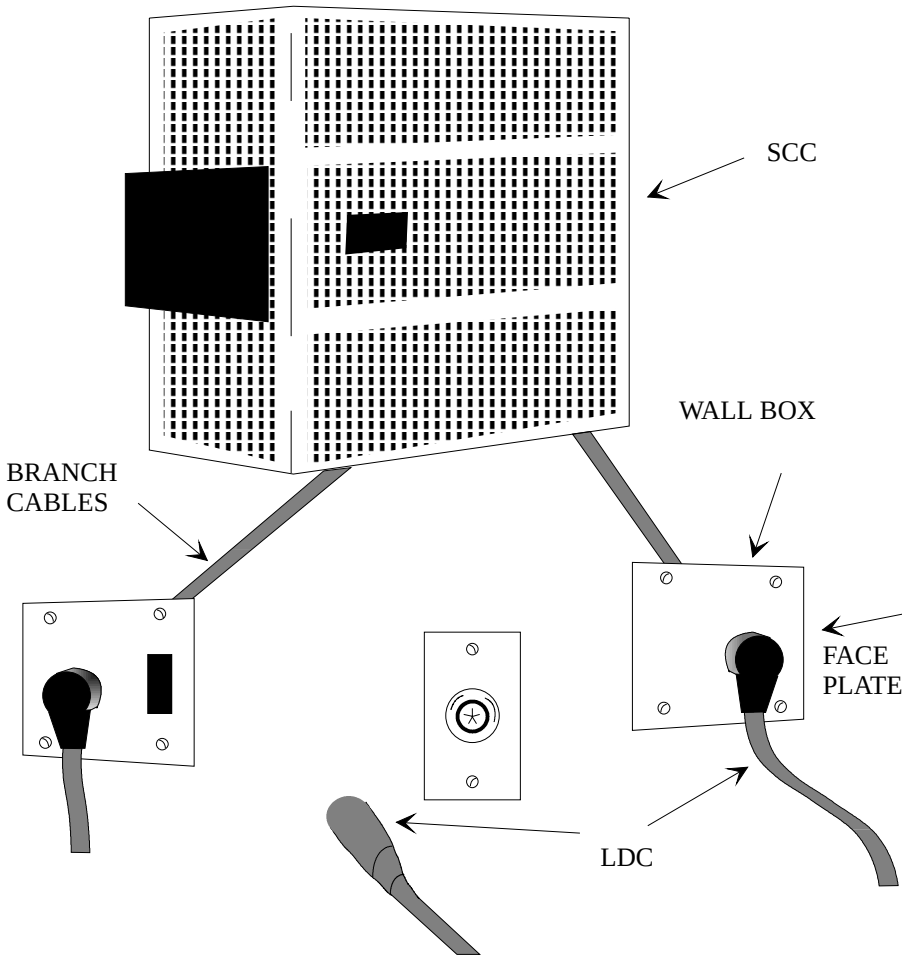


Figure 5-1 Philips monitoring network (SDN) System Components

Philips Care Hub (SCC)

The Philips care hub (SCC) is the central component of the serial distribution network. The Philips care hub (SCC) provides the physical system communications link to the instruments and systems connected to the Philips monitoring network (SDN). The Philips care hub (SCC) establishes the Philips monitoring network (SDN) data polling cycles and controls the flow, timing, synchronization, and distribution of data throughout the network.

The Philips care hub (SCC) also performs some basic fault detection routines to maintain the reliability of the Philips monitoring network (SDN) communications. The Philips care hub (SCC) includes self-diagnostic routines for fault detection, troubleshooting, and servicing.

The Philips care hub (SCC) is a metal chassis with cover and cable clamps, a power supply, and two PC boards.

Philips Monitoring Network (SDN) Interface Circuitry

The Philips monitoring network (SDN) interface circuitry is the intelligent interface between the Philips monitoring network (SDN) and the host microprocessor located in the CMS and the V24/V26. This interface circuitry sends and receives messages to and from other systems over the Philips monitoring network (SDN).

Wall Boxes and Face Plates

Wall boxes are of standard size, NEMA, 1- or 2-gang switch wall boxes with conduit knockouts (KOs). The face plates are prepunched, NEMA, 1- or 2-gang faceplates for Philips monitoring network (SDN) connectors.

Branch Cables

Branch cables are permanently installed cables that provide the long distance connection between the Philips care hub (SCC) and the wall box.

Local Distribution Cables (LDC)

The local distribution cables (LDC) are used for local serial connections from the wall box to CMS or V24/V26 systems. The LDCs can also be used to connect up to four separate instruments to one wall box. The LDCs provide the ability to move systems to different bedsides by connecting the systems to the wall boxes at the new locations.

How the Philips Monitoring Network (SDN) Works

The Philips monitoring network (SDN) uses a network configuration called a star topology. The Philips care hub (SCC) is the center of the star with up to 32 individual branches extending from the center. These branches can accommodate up to 24 bedside monitors, such as CMSs and V24/V26 monitors, with one patient per branch, up to six central stations, and two computer monitoring systems. Figure 5-2 illustrates a sample Philips monitoring network (SDN) configuration

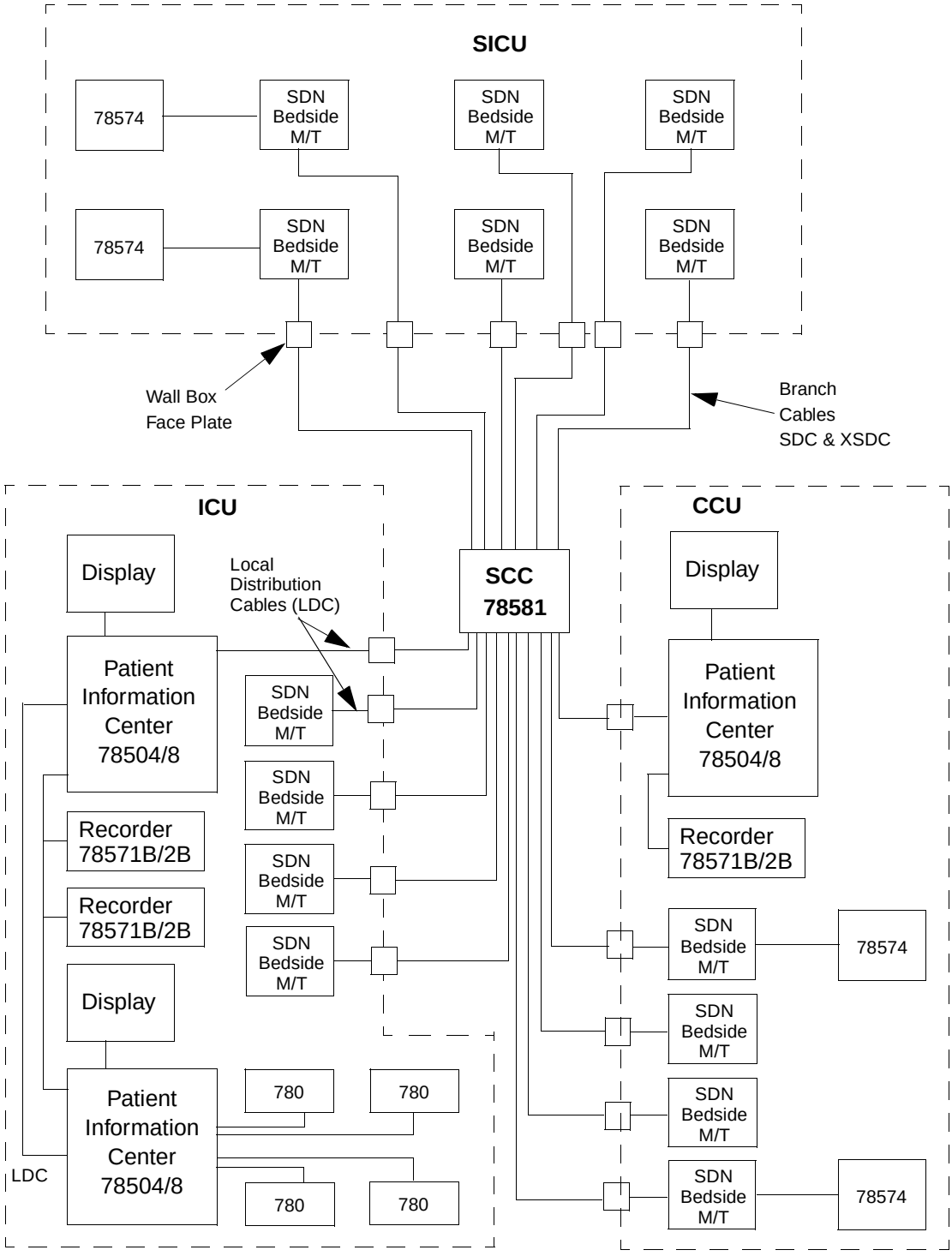


Figure 5-2 Sample Philips Monitoring Network (SDN) Configuration

The Philips monitoring network (SDN) transmits patient information serially at regular intervals called polling cycles to the Philips care hub (SCC). The Philips care hub (SCC) sequentially synchronizes and rebroadcasts the received patient information to all instruments connected to the Philips monitoring network (SDN). The Philips care hub (SCC) works in conjunction with the Philips monitoring network (SDN) interface circuitry located within each CMS and V24/V26 monitor connected to the Philips monitoring network (SDN).

The Philips monitoring network (SDN) interface circuitry sends and receives Philips monitoring network (SDN) data over the branch cables for Philips care hub (SCC) instrument-to-system communications. The Philips monitoring network (SDN) interface circuitry also sends and receives Philips monitoring network (SDN) data over the LDCs for instrument-to-instrument communications.

Only one CMS or V24/V26 monitor can broadcast patient information at any one time. The Philips care hub (SCC) rebroadcasts that information to the other branches on the Philips monitoring network (SDN). The Philips care hub (SCC) functions as a rotary switch, allowing each branch to transmit information to the other branches.

The Philips care hub (SCC) polls each branch 32 times per second. Figure 5-3 illustrates the poll cycle when the Philips care hub (SCC) polls a branch. The system on branch 0 sends all of its available information until the system is done. As branch 0 transmits its information, the Philips care hub (SCC) simultaneously rebroadcasts the information to the other 31 branches.

When the Philips care hub (SCC) senses the end of transmission from branch 0, the Philips care hub (SCC) turns off the branch 0 receiver. The Philips care hub (SCC) polls branch 1 and repeats the polling activity for each branch until all 32 branches have been polled.

If a branch has more than one monitor, the monitor connected closest to the Philips care hub (SCC) sends information first. When that monitor is finished, it signals permission to the next monitor so that it can send information. This process continues for each monitoring system on the branch. Each system gets the opportunity to send information, but no two monitors can send information at the same time. Also, any monitor can listen to the information being sent by the other systems.

A complete detailed description of the Philips monitoring network (SDN) communications cycle can be found in the SDN/SCC Service Manual supplied with your Philips monitoring network (SDN) Network.

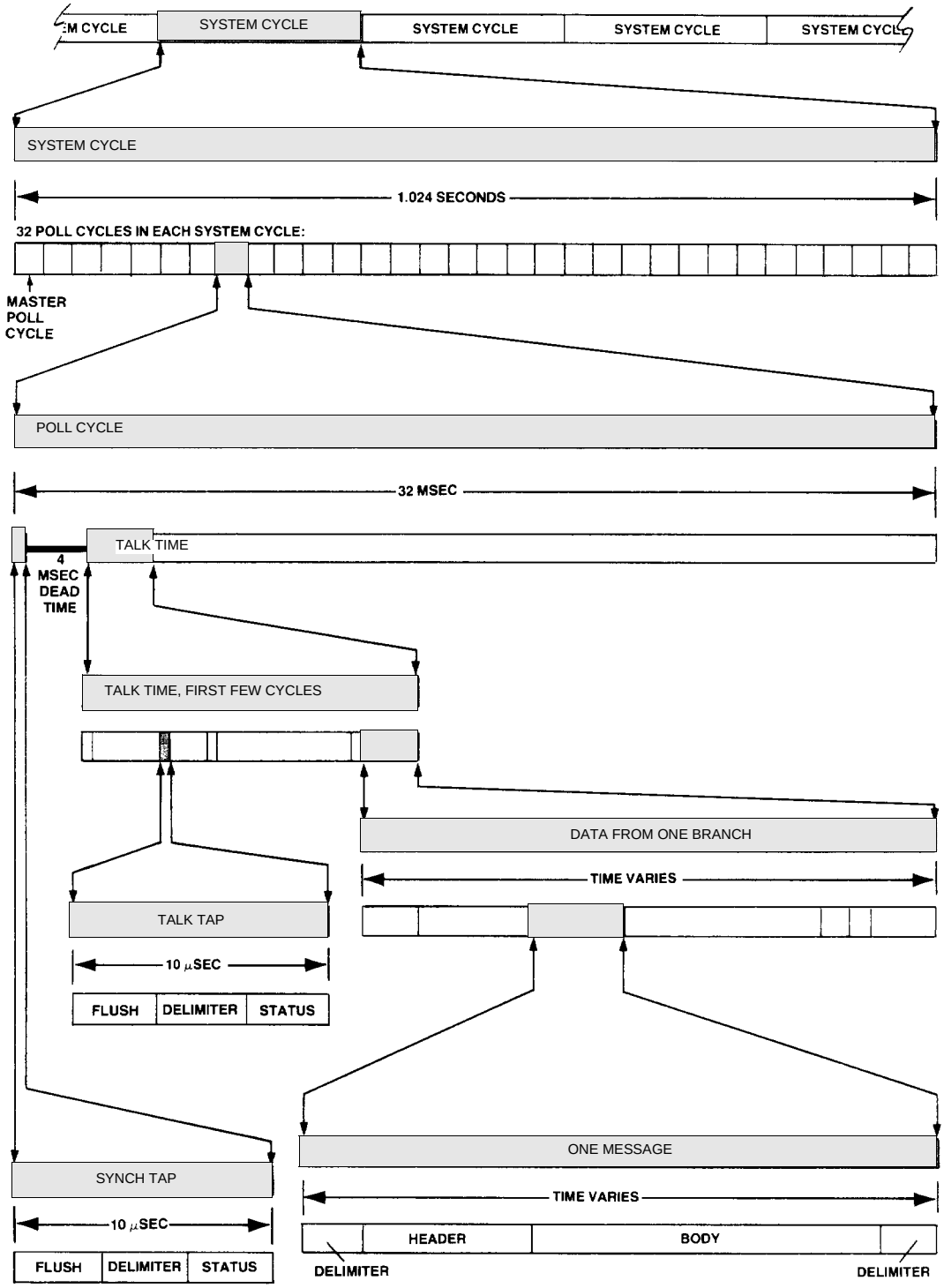


Figure 5-3 SCC Polling

Defining the Inter-SDN Gateway

The Inter-SDN Gateway provides data exchange between two Philips care hubs (SCC) using the virtual terminal protocol (VTP), a proprietary protocol of the Philips monitoring network (SDN). With the Inter-SDN Gateway, nursing staff can monitor patients, whose CMS or V24/V26 monitor is connected to one Philips monitoring network (SDN), from any CMS or V24/V26 monitor connected to the other Philips monitoring network (SDN). The CMS provides automatic alarm overview across two Philips care hubs (SCCs) and manual alarm overview across three Philips care hubs (SCCs).

You can only connect two Philips care hubs (SCCs) to an Inter-SDN Gateway, but you can connect a Philips care hub (SCC) to more than one Inter-SDN Gateway. Connecting a Philips care hub (SCC) to more than one Inter-SDN Gateway expands the number of bedsides that can be monitored at one CMS or V24/V26 monitor from 24 to 72.

Figure 5-4 illustrates a sample Inter-SDN Gateway configuration.

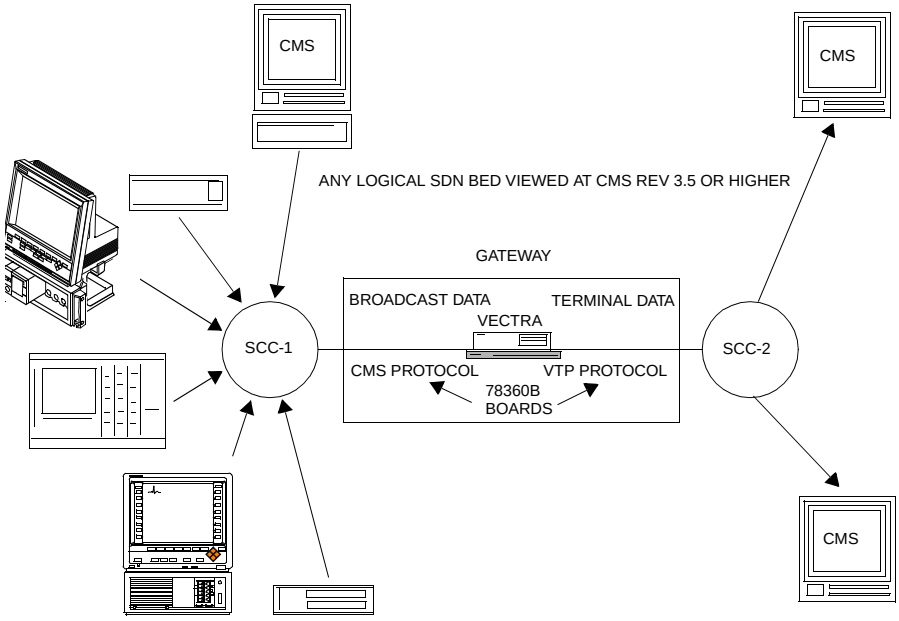


Figure 5-4 Inter-SDN Gateway Configuration

The Inter-SDN Gateway receives bedside broadcast data from one Philips monitoring network (SDN), formats the data into virtual terminal data, and sends those data to a specific CMS on the other Philips monitoring network (SDN). This extended overview has the following features:

- support for 24 bedsides on the local Philips monitoring network (SDN) and access to as many as 48 remote bedsides
- user-configurable access key at each local Philips monitoring network (SDN) bedside
- one wave, cascaded in two, four-second segments
- softkey to select specific waves for display
- up to seven parameter numerics
- alert text messages
- support for up to eight simultaneous remote access sessions in each direction, depending on availability of each Philips monitoring network (SDN) bandwidth

The Philips monitoring network (SDN) bandwidth is shared equally among six sending devices, such as Careport, 78360A, and 78360B, thus limiting the number of active sending devices on a Philips monitoring network (SDN) to six. If the Inter-SDN Gateway identifies less than six devices, the gateway takes all available bandwidth. This can limit the number of simultaneous overview sessions; that is, the more sending devices on the Philips monitoring network (SDN), the fewer the simultaneous overview sessions permitted. Furthermore, the type of overview session – manual or automatic alert – affects the number of simultaneous overview sessions permitted.

For manual overview, Table 5-1 lists the number of simultaneous overview sessions the Inter-SDN Gateway permits based on the number of sending devices installed on a Philips monitoring network (SDN).

Table 5-1 Number of Overview Sessions Using Manual Overview

Number of sending devices	Number of sessions
Four to six	Four simultaneous overview sessions in each direction for a total of eight overall sessions.
Two or three	Six simultaneous overview sessions in each direction for a total of 12 overall sessions.
One	Eight simultaneous overview sessions in each direction for a total of 16 overall sessions.

For automatic alert overview, Table 5-2 lists the number of simultaneous overview sessions the Inter-SDN Gateway permits based on the number of sending devices installed on a Philips monitoring network (SDN).

Table 5-2 Number of Overview Session Using Automatic Alert Overview

Number of sending devices	Number of sessions
Three or fewer	Four simultaneous overview sessions in each direction for a total of eight overall sessions.
Four to six	Two simultaneous overview sessions in each direction for a total of four overall sessions.

With four to six sending devices, the Inter-SDN Gateway can permit two simultaneous sessions if less than nine alerts are generated. If the number of alerts increases above eight, no overviews are permitted. If overview sessions are in progress, they are automatically dropped off.

The Inter-SDN Gateway is an HP Vectra personal computer with Philips monitoring network (SDN) interface circuitry. Figure 5-5 illustrates the front and rear view of the Inter-SDN Gateway, model M1272A.

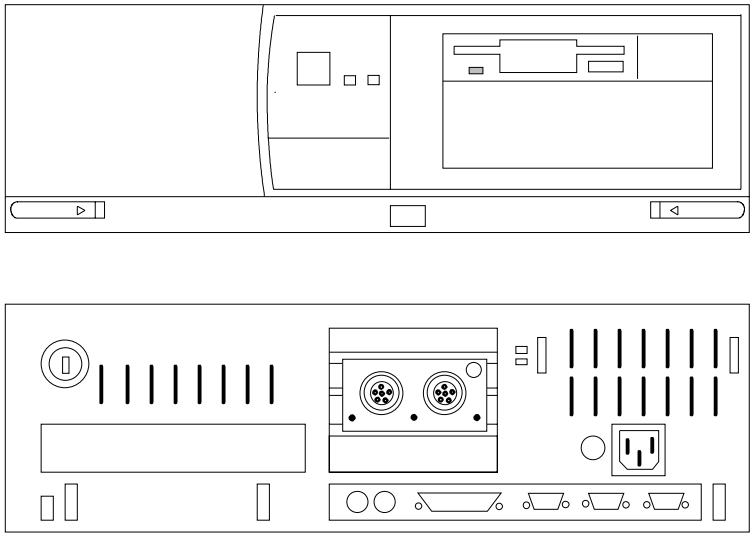


Figure 5-5 Front and Rear View of the Inter-SDN Gateway

Defining the Inter-SDN Gateway Exercises

1. The Philips monitoring network (SDN) is a:

a. system to which parameter modules are connected for translating patient physiological parameters and other data.
b. non-local area communication network for sharing patient physiological parameters and other data.
c. local area communication network for sharing patient physiological parameters and other data.

2. The Philips care hub (SCC) is the:

a. intelligent interface between Philips monitoring network (SDN) and the host microprocessor
b. central component of the Philips monitoring network (SDN)
c. local serial connections from the wall boxes

3. Philips monitoring network (SDN) uses a network configuration called:

a. star topology
b. planet topology
c. branch topology

4. How many Philips care hubs (SCCs) can you connect to an Inter-SDN Gateway?

a. two
b. four
c. six

Answers
1. c
2. b
3. a
4. a

A

Arterial Oxygen Saturation and Plethysmography (SpO2/PLETH) Module
  Block Diagram, 60
  Components, 60
  Description, 60
  Exercises, 65
  Features, 63
    Connectors, 63
    PLETH Waveform, 64
    Safety, 63
    User Controls, 63
  Measurements, 60
  Theory of Operation, 62
Arterial Oxygen Saturation via Pulse Oximetry (SpO2) Measurement
  Concepts, 56
  Criteria for Proper Measurement, 57
  Description, 56
  Measurement Acquisition, 57
  Measurement Principle, 57
  Output, 57
  Plug-In Modules, 58
  References, 58
Arterial Oxygen Saturation via Pulse Oximetry (SpO2) MeasurementExercises, 59

C

Cardiac Output (C.O.) Measurement
  Concepts, 40, 49
  Criteria for Proper Measurement, 42
  Description, 40
  Exercises, 43
  Measurement Acquisition, 40, 49
  Measurement Principle, 40, 49
  Output, 42
  Plug-In Modules, 42
  References, 42
Cardiac Output (C.O.) Module
  Block Diagram, 44, 52
  C.O. Module Features, 47, 55
  Components, 44
  Description, 44, 52
  Exercises, 48
  Features
    Connectors, 47, 55
    Safety, 47, 55
    User Controls, 47, 55
  Measurements, 44, 52
  Theory of Operation, 46, 54
CO2 Respiratory Gas Measurement
  Concepts, 20
  Criteria for Proper Measurement, 21
  Description, 20
  Measurement Acquisition, 20
  Measurement Output, 20
  Measurement Principle, 20
  Plug-In Modules, 21
CO2 Respiratory Gas Module (M1016A)
  Block Diagram, 23
  Components, 23
  Description, 23
  Exercises, 27
  Features, 25
    Connectors, 26
    Safety, 26
    User Controls, 26
  Measurements, 23
  Theory of Operation, 25

D
Data Transfer Module
  Block Diagram, 86
  Components, 86
  Description, 86
  Exercises, 90
  Features, 89
    Capabilities, 89
    Safety, 89
    User Controls, 89
  Theory of Operation, 88

E
ECG Measurements Exercises, 12
Electrocardiogram (ECG) Measurement
  Concepts, 3
  Criteria for Proper Measurement, 11
  Description, 3
  Measurement Acquisition, 3
    Chest Leads, 6
    Five-Electrode Placements, 8
    Limb Leads, 4
    Modified Chest Lead (MCL1), 7
  Measurement Principle, 3
  Output, 9
    ECG Waveforms, 10
    ST Segment, 10
  Plug-In Modules, 11
Electrocardiogram (ECG) Module
  Block Diagram, 13
  Components, 13
  Description, 13
  Exercises, 18
  Features, 16
    Connectors, 16
    Paced vs. Non-Paced Mode, 17
    QRS Detection, 17
    Safety, 17
    ST Segment Analysis, 17
    User Controls, 16
    Waveforms, 16
  Measurements, 13
  Theory of Operation, 15
Electrocardiogram/Respiration (ECG/RESP) Module
  Block Diagram, 24
  Components, 23
  Description, 23
  Exercises, 28
  Features, 26
    Connectors, 26
    ECG Modes, 26
    RESP Modes, 27
    Safety, 27
    ST Segment Analysis, 27
    User Controls, 26
  Measurements, 23
  Theory of Operation, 25

F
FIO2 Module (M1017A)
  Block Diagram, 35
  Components, 35
  Description, 35
  Exercises, 39
  Features, 37
    Connectors, 37
    Safety, 38
    User Controls, 37

Measurements, 35
Theory of Operation, 37
FIO2 Respiratory Measurement
Concepts, 33
Criteria for Proper Measurement, 34
Description, 33
Exercises, 34
Measurement Acquisition, 33
Measurement Output, 33
Measurement Principle, 33
Plug-In Modules, 34

I

Invasive Blood Pressure Measurement
Concepts, 3
Criteria for Proper Measurement, 4
Description, 3
Exercises, 5
Measurement Acquisition, 3
Measurement Output, 4
Measurement Principle, 3
Plug-In Modules, 4
Invasive Blood Pressure Module (M1006A)
Block Diagram, 6
Components, 6
Description, 6
Exercises, 10
Features, 8
Connectors, 9, 85, 95
Safety, 9, 85, 95
User Controls, 9
Measurements, 6
Theory of Operation, 8
Invasive Blood Pressure Module (M1006A/Option #C01)
Block Diagram, 11
Components, 11
Description, 11
Exercises, 15
Features, 14
Connectors, 14
User Controls, 14
Measurements, 11
Theory of Operation, 13
Invasive Blood Pressure Module (M1006B)
Block Diagram, 16
Components, 16
Description, 16
Exercises, 19
Features, 18
Measurements, 16
Theory of Operation, 18

N

Non-invasive Blood Pressure (NBP) Measurement
Concepts, 30
Criteria for Proper Measurement, 31
Description, 30
Exercises, 32
Measurement Acquisition, 31
Measurement Principle, 30
Output, 31
Plug-In Modules, 31
Non-invasive Blood Pressure (NBP) Modules
Block Diagram, 34
Components, 34
Description, 34
Exercises, 39
Features, 36

Connectors, 37
NPB Modes, 37
Safety, 38
User Controls, 37
Measurements, 34
Theory of Operation, 36

R

Recorder Module (M1116A)
Block Diagram, 73
Description, 73
Exercises, 79
Features, 77
Recordings, 77
User Controls, 77
Theory of Operation, 75
Recorder Module (M1116B)
Block Diagram, 80
Description, 80
Exercises, 85
Features, 83
Recordings, 84
User Controls, 83
Theory of Operation, 82
Respirogram (RESP) Measurement
Concepts, 19
Criteria for Proper Measurement, 21
Description, 19
Exercises, 22
Measurement Acquisition, 20
Measurement Principle, 19
Output, 21
Plug-In Modules, 21
References, 21

S

Sidestream CO2 Module (M1015A)
Block Diagram, 28
Components, 28
Description, 28
Exercises, 32
Features, 31
Connectors, 31
Safety, 31
Measurements, 28
Theory of Operation, 30
SvO2 Blood Measurement
Concepts, 50
Criteria for Proper Measurement, 50
Description, 50
Exercises, 51
Measurement Acquisition, 50
Measurement Output, 50
Measurement Principle, 50
Plug-In Modules, 50
SvO2 Module (M1021A)
Block Diagram, 52
Components, 52
Description, 52
Exercises, 57
Features, 55
Connectors, 56
Safety, 56
User Controls, 55
Measurements, 52
Theory of Operation, 54

T

Temperature (TEMP) Measurement
  Concepts, 66
  Criteria for Proper Measurement, 66
  Description, 66
  Exercises, 68
  Measurement Acquisition, 66
  Measurement Principle, 66
  Output, 66
  Plug-In Modules, 67
  References, 67
Temperature (TEMP) Module
  Block Diagram, 69
  Components, 69
  Description, 69
  Exercises, 72
  Features, 71
    Connectors, 71
    Safety, 71
    User Controls, 71
  Measurements, 69
  Theory of Operation, 71
Transcutaneous Gas Measurement
  Concepts, 40
  Criteria for Proper Measurement, 41
  Description, 40
  Exercises, 42
  Measurement Acquisition, 41
  Measurement Output, 41
  Measurement Principle, 40
  Plug-In Modules, 41
Transcutaneous Gas Module (M1018A)
  Block Diagram, 45
  Calibration Algorithm, 43
  Components, 45
  Description, 43
  Features, 48
  Measurements, 43
  Theory of Operation, 47

V

VueLink Module
  Block Diagram, 69, 81
  Components, 69
  Description, 68
  Exercises, 73
  Features, 71
    Connectors, 72
    Safety, 72
    User Controls, 72
  Measurements, 68
  Theory of Operation, 71